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STUDIES IN THE HISTORY OF GUJARAT

By

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PART I.—THE GUJARAT SULTANS AND THE PORTUGUESE—THE LAST PHASE

(Lectures delivered by the author, under the auspices of the University of Bombay, as the Thakkar Vassonjee Madhavji Lectures for 1930–31)

CHAPTER I

THE LAST DUEL BETWEEN THE GUJARAT SULTANS AND THE PORTUGUESE (1546): THE MUSLIM ACCOUNT

The siege of Div a great chapter in military history.

There is probably no military episode in the entire Muslim period of the history of Gujarat which has been described to us in such detail as the last determined effort made by the armies of Sultan Mahmud III of Gujarat in 1546 to recover the fort of Div from the Portuguese. No doubt, both Firishta and the author of the *Mirat-i-Sikandari* are completely silent on the subject; but Hajji-ad-Dabir in his Arabic History has a fairly long account of this conflict. The Portuguese historians and biographers, on the other hand, describe this episode at great and almost tedious length, and the struggle appears to have made a tremendous impression on contemporaries both in Asia and in Europe. Though the accounts of this famous siege are partially one-sided, and though the Portuguese writers naturally extol the success and heroism and, we might add, the brutality of the victors, there is enough authentic material available to us to arrive at a balanced judgment on this memorable incident which finally confirmed the Portuguese in the possession of this once celebrated centre of trade in the Eastern seas.

(i) *The Theatre of the War*

The island and town of Div.

The island of Div, generally described by Arab and Portuguese historians as Diu,[1] is situated at the southern extremity of the peninsula of Kathiawar, being separated from the coastland by a narrow channel of water through a considerable swamp which readily admits of connection by road. The extreme length of the island is about seven miles from east to west, and its greatest breadth from north to south two miles. The area is about 20 square miles. On the north the narrow

1. We have used throughout these chapters the correct form of the name of this place, viz., Div, under which it has been known to the Hindus for many centuries, the word being derived from the earlier Sanskrit form *Dwipa*, which means an island. The Arab and the Portuguese mariners and writers describe the place as Diu, and this form has been retained in the English language and in all official maps. The author of the *Arabic History of Gujarat* says: "The Indians spell the word as Dib (Div) and that is the correct spelling but the Arabs have changed it into Diu" (Vol. I, p. 38). Mir Abu Turab, in his brief *History of Gujarat* in Persian, spells the word in three different ways, viz., Dib, Dip, and Div. The Portuguese historians also often use the form Dio.

channel separating it from the mainland is practicable only for fishing boats and small craft. The town of Div, with its once famous castle, stands at the east end of the island, and, in the days of its prosperity during the 15th and 16th centuries, it is said to have contained an enormous population, being also embellished with several magnificent edifices, some of which are still in existence. Besides foreign trade, the principal occupations of its inhabitants were formerly weaving and dyeing, and articles manufactured here were highly prized in foreign markets. But once so opulent and famous for its commerce, Div has now dwindled into utter insignificance, standing far away from the great trade-routes of which it was once the centre, and fishing now affords the chief employment to its impoverished inhabitants.[1]

Account of the city of Div by Varthema, 1504.

Some idea of the enviable position enjoyed by the town of Div during the sixteenth century as an emporium for the trade of Western and Northern India may be obtained from the accounts left by two European travellers, Varthema and Barbosa, who visited it during the opening years of this century. The earlier of the two was Ludovico di Varthema, a native of Bologna in Italy, who arrived at Div in 1504 in the early part of his very extensive travels to Eastern lands. This is what he says :—

" When we had sailed about twelve days (from Barbera on the Somali coast in Africa) we arrived at a city which is called Diuobandierrumi (*Diu-Bandar-er-Rumi*),[2] that is, ' Diu, the port of the Turks,' which city is situated a short distance from the mainland. When the tide rises it is an island, and when it falls you can pass over on foot. This city is subject to the Sultan of Combeia (Cambay) and the captain of this Diu is one named Menacheaz (Malik Ayaz). We remained here two days. There is an immense trade in this city. Four hundred Turkish merchants reside here constantly. The city is surrounded by walls and contains much artillery within it."[3]

Barbosa's account of Div, *c.* 1515.

The travels of Duarte Barbosa, a Portuguese official who served in India mainly at Cochin and Cannanore from 1500 to 1517, and who visited Gujarat about 1515, some ten years after Varthema, enable us to obtain

1. The entire population of the island of Div, according to the Census of 1900, numbered 14,614 persons, of whom 343 were Christians, including 3 Europeans.

2. The principal anchorage in the harbour of Div is invariably referred to by Muslim historians as the *Bandar-at-Turk*, which is the same as the Bandar-er-Rumi mentioned by Varthema. *Cf. Arabic History of Gujarat*, Ed. by Sir E. Denison Ross, Vol. I, 220, 251, 261, 277.

3. *Travels of Ludovico di Varthema*, trans. and ed. by Jones and Badger (Hakluyt Society Publications), 91-92.

another interesting account of the wealth and commerce of the port of Div in the early years of the 16th century. Barbosa's record of his travels enjoyed a high reputation for veracity and exactness in his day and was accepted as such by the great Portuguese historians of the period such as João de Barros and Gaspar Correa. Barbosa mentions more than a dozen sea-port towns on the coast of Malabar in south India, as well as on the coasts of Persia, Arabia and East Africa, with which Div had trade relations, and he enumerates in detail a large number of commodities, both raw materials and manufactured goods, which were handled in the great import and export trade of Div :

" So that this town is the chief emporium of trade which exists in all these parts. It gives such a large sum of money as revenue to the king, for the loading and unloading of such rich goods, that it is a subject of marvel and amazement."[1]

The accounts of Div given by Varthema and Barbosa both refer to the opening decades of the 16th century; we shall now give a third reference by the traveller Caesar Frederick who visited the place in 1563, during the second half of the same century, and some twenty years after the gallant defence of the fort by the Portuguese in the second siege of Div by the Muslims. Caesar Frederick was a Venetian merchant who spent 18 years of travels in the East (1563-81) and whose account is an accurate record. Div was the first port which he visited in India, and he writes thus about it :

Caesar Frederick at Div, 1563.

"There (at Ormaz) I shipped myself to go for Goa, a city in the Indies, in which passage the first city that you come to in the Indies is called Diu, and is situate in a little island in the Kingdom of Cambaia, which is the greatest strength that the Portugals have in all the Indies, yet a small city, but of great trade, because there they lade very many great ships for the straights of Mecca and Ormus with merchandise and these ships belong to the Moors and Christians, but the Moors cannot trade, neither sail into those seas, without the license of the Viceroy of the King of Portugal, otherwise they are taken and made good prizes. The merchandise that they lade these ships withal commeth from Cambaietta (Khambayat), a Port in the Kingdom of Cambaia, which they bring from thence in small barks, because there can no great ships come thither, by reason of the sholdness of the water thereabouts."[2]

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1. *A Description of the Coasts of East Africa and Malabar* by Duarte Barbosa, trans. by Stanley, (Hakluyt Society), 1866, p. 60. Another translation has more recently been published by the same Society entitled *The Book of Duarte Barbosa,* trans. and ed. by M. Longworth Dames. (Cf. Vol. I, pp. 130-32.)

2. *Purchas His Pilgrimes,* by Samuel Purchas (James Mac Lehose, Glasgow, 1905) Vol. X, 89-90.

The famous Portuguese fort of Div, as reconstructed by Dom João de Castro after the siege of 1546, with several later improvements, still remains an imposing structure situated to the extreme east of the island, and it is defended by several pieces of cannon. The castle is separated from the other fortifications by a deep moat cut through the solid sandstone rock, through which the sea had free passage at one time, but now it enters only at the highest tides. The imposing water bastion of the fort, on the side facing the sea, had to bear the brunt of the cannonade from the Turkish fleet under Sulayman Pasha during the first siege of the castle in 1538. But the second siege of 1546, with which we are here concerned, was entirely by land and it was carried out by the armies of the Gujarat ruler without any help from a foreign power. The generals of Sultan Mahmud III, therefore, naturally directed all their attacks on the line of the fortifications facing the city, which contained three bastions, viz., that of St. John, at the head of the narrow channel between the island and the mainland; that of St. Thomas at the opposite side; and, lastly, that of St. James.

The famous Portuguese fort at Div.

The island of Div was long coveted by the Portuguese from the days of the great Albuquerque onwards. But under the famous Sultan Mahmud Begada all their efforts to secure a footing on the island were frustrated by the unbending opposition of Malik Ayaz, the great admiral of that sultan who was governor of Div for many years. The Portuguese, however, obtained their desire towards the end of the reign of Sultan Bahadur in 1535, when under the stress of the Mughal invasion of the province permission was given to them to build a fortress on the island in return for some help. On the tragic death of Bahadur at sea in 1537, after his interview with the famous Viceroy Nuno da Cunha on board the latter's ship, the Portuguese obtained possession of the town of Div, and not all the efforts of the Gujarat ruler during the next ten years were able to dislodge them.

The Portuguese covet and secure the place.

(ii) *The Principal Actors in the Siege of Div*

The ruler of Gujarat at this critical period was Sultan Mahmud III, a nephew of the great Bahadur, and an immature and unwarlike youth who had inherited neither the valour nor the capacity of his distinguished predecessors on the throne. Under him the decline of this powerful kingdom began. The noble, who held one of the most commanding positions at the Gujarat court, and who took the foremost part in the operations during the early months of the siege of Div, was Khwaja Safar Salmani, a name corrupted by the Portuguese writers into

Career of Khwaja Safar Salmani.

"Coge-Sofar" and other variants. His career was a romantic one. Born a European, being an Albanian of Catholic parents, he began life as a military adventurer and served in the armies of Italy and Flanders. He was later taken captive at sea by Sulayman Pasha, Admiral of the Sultan of Cairo, who presented him to his master. Here the captive rose by virtue of his experience in war and capacities to the high position of Treasurer of Cairo. But his pride and his ambition roused the envy and opposition of the Turkish nobles, so that the Sultan was constrained to force him to abandon his religion and he changed his Christian name into that of Khwaja Safar by which he is known to history.[1]

He arrives in Gujarat under Bahadur.

After some further service, apprehensive of retaining the continued confidence of the Sultan of Cairo, Khwaja Safar left Egypt and in time arrived at the court of Sultan Bahadur in Gujarat who was known for the patronage he extended to foreigners especially to those who had any experience of the wars and policy of Europe. He soon established himself completely in Bahadur's confidence and was present during the Sultan's unlucky visit to the Portuguese Viceroy Nuno da Cunha in 1537, and at the scuffle which attended his death. In 1538 he presented himself before the new Sultan Mahmud III who gave him the title of Khudawand Khan and made him Governor of Surat. Khwaja Safar played an active part in the first siege of Div in 1538 when the combined forces of Gujarat and Turkey made a determined attempt to recover the fort from the Portuguese; and the failure of that effort made him now, after eight years, doubly anxious to revenge the disgrace and to recover from the foreigner the control over this wealthy emporium of commerce.

Dom João de Castro, 'Governor of India.'

The name of Dom João de Castro, the Governor of Portuguese India at this period, is most intimately associated with this second siege of Div. He was born at Lisbon in 1500 and was a scion of one of the noblest and most illustrious families of Portugal, one of his ancestors having been First Constable who traced his descent to the Kings of Navarre. At the age of eighteen, he joined the Portuguese army at Tangiers in Africa where he first gave proofs of his courage. Returning home in 1527 he lived a private life for nearly ten years at his country seat in Cintra. He put on his sword again in 1535 to follow the Eagles of the Emperor Charles V in the Tunis Expedition, where he added fresh glory to his name. He refused on this occasion

1. *The Life of Dom John de Castro*, by Jacinto Freire de Andrada, trans. from the Portuguese into English by Sir Peter Wyche, Kt., London, 1664, pp. 54–7.

his share of a present of money that Charles made to the Portuguese officers, saying that 'he served the king of Portugal, and of him alone he expected a reward'. In 1538 he sailed in the fleet of Dom Garcia de Noronha, the third Viceroy of India, and saw his first service in this country.[1] On his return home about 1543, his sovereign King John III made him Admiral of the Navy of the coast, and his last public service began when, on the recommendation of the Infante Dom Luiz, he was sent in 1545 to India as Governor, where he secured those victories which added to the reputation of Portugal in the East.[2]

His signal services during the siege.

To Dom João de Castro not less than to the commander of the fortress belongs the credit of ultimately securing the relief of the fort of Div and the defeat of the large forces that were ranged against it. He arrived at Goa in September, 1545, a few months before the commencement of the siege, and brought with him his two sons, Dom Alvaro and Dom Fernando, both in the prime of youth, and men of high courage and promise who took an active part in the military operations of the siege. The governor now proclaimed war "at fire and sword" against the king of Gujarat with legal solemnities so as to justify his motives. He wrote specially to the people of Bassein that being nearest to Div they were bound to give help, particularly in their own interest, for the guns that battered Div were shaking the houses of Bassein. De Castro also busied himself with providing relief for the fortress, and, as the treasury was empty, he asked for and obtained large sums from the merchants on the pledge of his word, for his reputation stood high in the Indies.[3]

1. Dom João de Castro's appointment as Governor of Portuguese India in 1545 was thus not his first service in these parts. When he sailed with Garcia de Noronha, the king offered him a 1000 Crusados annually and the command of the fort of Hormaz. He declined the latter but accepted the money as being poor. His eldest son, Alvaro, then only 13 years old, accompanied him. On reaching India, the Viceroy Garcia de Noronha took charge of the expedition, prepared by his predecessor Nuno da Cunha, to proceed to Div which was besieged in 1538 by the Gujarat and the Turkish fleets. Dom João de Castro offered himself for service in the very first ship that was going, "as if he foresaw those future triumphs Div called him to." His log of this voyage to Div is of great value, especially his description of the Caves of Elephanta. —Whiteway, R. S., *The Rise of Portuguese Power in India*, 299-300 and *n*.

2. *The Life of Dom John de Castro*, op. cit., 269-70; Danvers F. C., *The Portuguese Power in India*, I, 483-4.

3. Ibid., 84-5. In this crisis D. João de Castro turned for help to Islam Shah of Delhi, the successor of the great Afghan ruler Sher Shah Sur, and suggested that he should attack Gujarat. The embassy did not meet with a very favourable reception. (Whiteway, *The Rise of Portuguese Power in India*, 305 *n*).

Dom João Mascarenhas, Captain of Div fort.

Dom João Mascarenhas was at this time the Portuguese commander at the fortress of Div. Having come to know about Khwaja Safar's designs against the fort he sent the information to the Governor at Goa urging upon him the need for men, ammunition and other necessities, the provision of which had been neglected during several years of peace under a sense of security based upon the former victory. The commander added that the rainy season was very near which would shut off all relief, and he busied himself with laying up provisions as further supplies were uncertain. After the blockade had begun, the soldiers, not more than 200 in number, were reserved for fighting purposes only, the slaves and others not fit to bear arms being engaged in the task of carrying lances, powder, stones and provisions to the defence-works. The women and the old men in the garrison were also employed on suitable duties. The captain put heart into his garrison by saying that the enemy were not now more numerous than those who were beaten during the first siege.

(iii) *Muslim account of the Expedition against Div as given in the "Arabic History of Gujarat"*

Value of the *Arabic History of Gujarat.*

Before proceeding further, we shall review the only available account of the siege of Div which has been handed down to us by a Muslim historian, viz., that given by Hajji-ad-Dabir in his Arabic History of Gujarat. As already mentioned, while the Persian histories of the province, such as the *Mirat-i-Sikandari* and Firishta's work, are completely silent on the subject of this great episode, a very detailed account is available in this Arabic history.[1] This is particularly valuable for various reasons and helps us to confirm or supplement the elaborate chapters of the Portuguese writers on the subject. In the first place, the Arabic historian gives us the correct names and titles of the various Gujarat generals who were engaged in this expedition, and points out the jealousy and lack of co-ordination that existed between the foreign and the native officers who served under the Gujarat Sultan. Moreover, Hajji-ad-Dabir gives the numbers of the combatants and the casualties on both sides as estimated by a Muslim writer. Lastly, his account is of special importance for giving us the terms of the treaty of peace concluded between the Gujarat ruler and the Portuguese Viceroy at the end of the war. In general, it may be stated that, in spite of very natural differences in matters of detail,

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1. The author's best thanks are due to his friend Mr. Muhammad Ibrahim Dar, M. A., for his valuable help in the translation of the relevant portion of Hajji-ad-Dabir's *Arabic History*.

the native and the foreign records about the siege of Div confirm each other in many important respects.

Afzal Khan's jealousy of Safar (Khudawand Khan).

We learn from the *Arabic History* that Afzal Khan Bimbani,[1] the famous vazir of Sultan Mahmud III, and Khudawand Khan (Safar Salmani) the powerful governor of Surat, were not on very friendly terms. In H. 953 (A. D. 1546) a ship belonging to Afzal Khan foundered in the harbour of Khandivi (Gandevi) which place was under the jurisdiction of Khudawand Khan, and one box full of gold *ashrafis* was lost in the waters. The port officers, in whose hands the box was suspected to have fallen, disclaimed any knowledge of or responsibility for the lost treasure. This led the vazir to devise some plan for the destruction of Khudawand Khan's person and property.

He commissions Safar to take Div.

One day, when both Afzal Khan and Khudawand Khan were at a court assembly (*diwan*) at Ahmadabad, the conversation turned on the high-handed conduct of the Turkish admiral Sulayman Pasha at Div which had led to the failure of the Gujarat armies during the first siege of that fort in 1538, and Afzal Khan turning to Safar said: 'God willing, the conquest shall be accomplished at your hands.' Khudawand Khan pointed out that the people of the coast towns were carrying on the trade in timber from the port of Purmin (Purmiyani)[2] to Mahim[3] and Tarapur;[4]

1. Afzal Khan Abd-us-Samad Bimbani was vazir under Sultan Bahadur, but on the death of this ruler at sea in H. 943 (A. D. 1537) he resigned his office and retired into private life. In the reign of Mahmud III, the nephew and successor of Bahadur, he returned to office, but was dismissed in 1547 after the failure of the operations against Div. The villain Burhan, after the murder of Sultan Mahmud and his two vazirs Asaf Khan and Khudawand Khan in H. 961 (A. D. 1554), called Afzal Khan to his presence and offered him the vazirate, saying that he was now the Sultan. But the pious and loyal ex-minister refused and was killed in the royal palace at Mahmudabad on the same night as the others (Feb. 16, 1554).

Notwithstanding his high position and wealth, Afzal Khan lived a life of piety and devotion. When he sat on his *gadi*, or official cushion, during the period of his power, a servant would by his order hold up a shroud and say: 'Afzal Khan, be not proud of thy present position; death approaches, and thou shalt be wrapped in this shroud; worldly honour and rank pass away; beware of the last day of Judgment.'—*Mirati Sikandari*, trans. by Fazlullah, 203-4; 249-50; *Mirati-Ahmadi Supplement*, trans. by Nawab Ali and Seddon, 1928, p. 78.

For Afzal Khan's rauza and mosque at Ahmadabad, see *post* p. 14 *n*.

2. Purmin is not to be found on any modern map of Kathiawar. It is not even mentioned in the long list of 62 centres of trade which, according to the Gazetteer of Kathiawar, existed in 1842 extending from the Gulf of Cutch to the Gulf of Cambay (*Bombay Gazetteer*, Vol. VIII, p. 236 and *n*). Unless we identify it with Porbandar it is difficult to locate it. I have, however, been able to find one very full and interesting reference to it in Capt. Alexander

they were under the protection of the Sultan, and if any hostilities were started against the Portuguese without giving them warning, they would be at the mercy of the Firangis. He suggested, therefore, that the expedition against Div might be postponed until these ships had returned to their ports; after this the trade in timber would be stopped by proclamation and the people warned against the danger of going out to sea. Afzal Khan, however, was not for any delay, and when Safar further urged that his men, money and ships of battle were out at sea, the vazir, 'who was more anxious for revenge against him than for extirpating the Firangis or conquering Div,' clinched the argument by saying that the resources of the public treasury would be at his disposal as well as the services of the foreign generals in the Kingdom.[1]

Safar at Sarkhej: he sends for his army and generals.

Khudawand Khan had no other alternative but to ask the permission of the young Sultan for the enterprise. Proceeding to Sarkhej, he sought the blessings of Shaikh Ahmad Khattu (Shihab-ud-din Qutb-ul-Ahad Ahmad) at the tomb of the saint and distributed alms. He also wrote to his agent (*vakil*) at Surat, Yaqut Bahr Khan, the Mamluk, ordering him to send up his son Muharram Rumi Khan with

Hamilton's *New Account of the East Indies*. After an account of the sea-port towns of Bet (the stronghold of the Sanganian pirates), Jagat or Dwarka, and Mangrol, he says: "The next place is Poremain a pretty large town on the sea-shore, and admits of trade, producing the same commodities as Mangaroul, and its inhabitants are of the same religion (*i. e.*, Banyans); but both towns are obliged to keep Rasspouts (Rajputs) to protect them from the insults of the Sanganians." After 'Poremain', the two other maritime towns on this coast mentioned are Div and Gogha. (A. Hamilton, *A New Account of the East Indies from the year 1688 to 1723*, Edinburgh, 1727, Vol. I, p. 134.)

Another reference of a much earlier date is contained in the *Mirat-al-Mamalik* written by Sidi Ali Rais, the famous Turkish admiral who was stranded on the Gujarat coast in 1554. He says that a Gujarat noble named Nasir-al-Mulk, who was opposed to Sultan Mahmud III, called in the aid of the Portuguese governor at Goa, promising that in return for his services the harbours on the coast of Gujarat, viz., Daman, Surat, Burudj (Broach), Ketbaye (Cambay), Samenat (Somnath), Minglur (Manglor or Mongrol) and Furmeyan, should be thrown open to the Portuguese. (*Travels and Adventures of Sidi Ali Reis*, trans. by A. Vambéry, p. 27.)

3. This is Kelve-Mahim, the head-quarters of the Mahim *taluka* of Thana District in the Bombay Presidency. It is situated about 5½ miles west of the Palghar station on the B. B. & C. I. Ry., and 56 miles north of Bombay. The village of Kelve, whose name is thus joined with Mahim, lies on the opposite side of a creek about 2½ miles to the south. (*Imp. Gazr.*, XV, 198.)

4. Tarapur-Chinchani is a port and group of two villages in the Mahim and Dahanu *talukas* of Thana District. The village of Chinchani lies on the north bank and Tarapur on the south bank of the Chinchani-Tarapur creek, 15 miles north of Mahim. (*Imp. Gazr.*, XXIII, 250.)

1. *Arabic History of Gujarat* by Hajji-ad-Dabir, ed. by Sir E. Denison Ross, Vol. I, 274.

an army, treasures and cannon.[1] Safar now led the expedition against Div in the beginning of H. 953 (A. D. 1546) with his artillery and 4,000 of the foreign troops (Turks, Habashis, etc.), his right wing being led by Bilal Jhujhar Khan, while Qara Hasan (later ennobled with the title of Jahangir Khan) was in charge of the left, and Muharram Rumi Khan was in the front. Mujahid Khan Bahlim, Naib-as-Saltanat, a native general, joined Safar with the army of Palitana and its dependencies. When Khudawand Khan reached Nawanagar on his way to Div, he left his heavy baggage there and advanced with his guns and fighting troops. Mujahid Khan, however, did not co-operate actively and lagged behind, but two of his officers, viz., Daulat Khan Dakkani and his brother Hasan Khan followed the banner of Safar.[2]

The siege of the Fort begins.

The siege of the castle of Div now commenced, and under cover of the fire from his guns Khudawand Khan gradually advanced upto the ditch which he got filled up in parts with earth. Afzal Khan, the vazir, accompanied by the Sultan, now came to Div as if on an excursion, but after three days both went away, and with them left Mujahid Khan in whose place Burhan-ul-Mulk was appointed in charge of the native troops (as distinguished from the Turks and other foreigners who were under Khwaja Safar, Jhujhar Khan and others). Finding that he was running short of money and that Afzal Khan failed to supply his needs, Safar again wrote to his agent Ya'qut Bahr Khan at Surat who forwarded to him funds in rapid succession. As the result of the cannonading many Portuguese in the fort were killed, and others became sick in consequence of the bad smell; while the provisions of the garrison also ran short. Safar continued to raise up walls or ramparts of stone and in doing a great deal of execution among the enemy with his fire until the cannon from the fort were almost silenced.[3]

Death of Safar, 1546: his son Rumi Khan takes his place.

But one day, while Khudawand Khan was sitting near a rampart, he was recognised by the people from the bastion of the fort, and a gunner fired a shot which hit a stone and a splinter struck Safar with such force that he was killed, H. 953 (1546). The choice of the foreign troops now fell upon his son Muharram Rumi Khan. He was still a youth, but was ably supported by Jahangir Khan (Qara Hasan) and Jhujhar Khan who were determined to help him to equal his father in generalship and reputation.[4] Jahangir Khan now laid a mine under one of the towers of the fort of Div, and, in the explosion that followed, the bastion was blown up and along with it 700 of the Firangis. Rumi Khan and Jahangir Khan were for entering the castle with their men

1. *Arabic History of Gujarat*, op. cit., 275.
2. Ibid., 275. 3. Ibid., 276. 4. Ibid., 276.

by an assault, but Burhan-ul-Mulk, who was the commander of the army (*amir-al-jaish*), held back and this lack of co-operation frustrated the design.[1]

Jhujhar Khan enters the castle: he is killed, Aug. 1546.

At night, however, Jhujhar Khan proceeded to climb up the walls of the fort with a scaling ladder. He did so with several of his soldiers and entered the castle. A bugler, however, in their company sounded his horn before all the party had entered. The Portuguese in the castle, thus warned, attacked the party of Muslims who had entered and who were few in number. Jhujhar Khan, finding his position untenable, tried to retire, but he was killed by a bullet in the forehead as he was putting his foot on the wall of the bastion to get down. The ladder also broke down in the rush of the soldiers. Jhujhar Khan and his followers who were in the castle became martyrs in Jumad-al-akhir of the year 953 H. (August, 1546).[2]

The Viceroy of Goa arrives at Div.

The rainy season being over, the sea was open for navigation and traffic, and the Viceroy (*Baizri*) Saheb of Goa reached Div with a large expedition and anchored at the Turk Bandar. Coming up in a ship to inspect the castle he saw the effects of the Gujarat artillery and the weak position of the Portuguese. At midnight he ordered all the cannon in the fleet to discharge a volley and at dawn he entered the castle with 30,000 Firangis. It appears that at this critical period there were grave dissensions between the foreign and the native forces in the Muslim camp. The former were in favour of Rumi Khan, while the native troops would only follow the lead of Burhan-ul-Mulk Muhammad-ul-Bimbani, and yet both were inexperienced men. In fact, after the death of Khudawand Khan and Jhujhar Khan, says the historian, Jahangir Khan was the only general in the Gujarat camp capable of opposing the enemy.[3]

Great battle of Div: defeat of the Muslims.

The viceroy of Goa issued from the castle when the sun rose 'to the length of a spear' and he had with him 30,000 men drawn up in line for action. The battle was a furious one but ultimately 'ended in misfortune in writing about which the pen dries up'. One cause of the disaster appears to have been the defection of Burhan-ul-Mulk during the battle, for the historian says: 'Had he stayed with his men he would have been an auxiliary to the Muslims; but he fled away.' The Muslims were reduced in numbers, while the Firangis, says our authority, outnumbered them. Three hundred perished in the collapse of a wooden bridge over the ditch and among these were Rumi Khan

1. *Arabic History of Gujarat*, op. cit., 276.
2. Ibid., 276.
3. Ibid., 277.

and Daulat Khan Dakkani, while Jahangir Khan escaped. According to the *Arabic History*, the total number of Muslims killed at Div was 2,500 while 2,000 more were wounded, and Jahangir Khan escaped with another 4,500. As for the Portuguese, 1,706 of them died in the castle during the siege, while 11,100 were slain fighting on the battle-field.[1]

Jahangir Khan returns to Ahmadabad.

After this disaster, Qara Hasan (Jahangir Khan) passed a night at Nawanagar and thence proceeded to Ahmadabad. The Sultan granted him an interview and asked for news about the war: when the general was relating the events of the battle, the king was shedding tears. The Sultan next summoned the soldiers and made enquiries about the part each had played, and distributed robes of honour to all of them. Qara Hasan was placed in charge of the artillery and the Sultan conferred upon him the title of *Al-majlis al mansur Jahangir Khan*, under which he has been mentioned in this history.[2]

The Sultan's fresh preparations against the Portuguese.

The King gave Jahangir Khan orders to cast more cannon with which the capture of Div might be effected; and the officers in charge of the ports of Gujarat received instructions not to permit the Firangis to put up at or have free access to their harbours. Orders were also issued for the collection of teakwood with which to build new ships, and a ready response was made by the port officers at Surat, followed by those of Broach, Gogha, Daman and Cambay, with the result that 1,500 ships were put to sea besides those already in the ports. Before a year had passed, Jahangir Khan had cast one hundred cannon on each of which were inscribed the words 'Jahangir Mahmud Shah'. A public announcement was made to the effect that the Sultan's government divested itself of all responsibility with regard to those, be they Muslim or non-Muslim, who held any commercial dealings with the Firangis, or who gave them accommodation at Div. Thus Div came for a time to be abandoned and Navanagar began to flourish; a strong fort was built there and it became the headquarters of the army. The Sultan next sent for Rajab, the other son of Khudawand Khan, who waited upon the king in the company of his agent Bahr Khan. On him was conferred the title of Rumi Khan which had been held by his father and his brother, and he was given permission to return to Surat.[3]

The failure of the attack on Div led to the dismissal of the Vazir, Afzal Khan,[4] on February 21, 1547, and in his place Abdul Halim, son

1. *Arabic History of Gujarat*, op. cit, 282.
2. Ibid., 283.
3. Ibid., 283.
4. The Rauza of Afzal Khan Bimbani is situated outside the city walls of Ahmedabad between the Raepur and the Sarangpur gates. Here he also founded a suburb called Afzalpur, which had in it, besides

of Hamid-ul-Mulk, was appointed as minister with the title of Khudawand Khan.[1]

Broach burnt by the Portuguese, Apr.-May, 1547.

In the month of Rabi-ul-awwal of H. 954 (April-May, 1547), the Portuguese fleet reached Broach, at this time a prosperous and flourishing port, and the men from the ships, taking advantage of the negligence of its *Amir* Ali Khan Saiyid Baranahar al-Mandawali, entered the fort there and burnt a portion of the city. The inhabitants of the place fought the invaders both singly and in groups and drove them back to their ships which were in the river just by the fort. The cannon in the bastions directed their fire against them, as the result of which some of their vessels were sunk and the rest escaped down the banks of the river Narbada to the fort of Bharbhut[2] which is situated some *parsangs* from Broach. Here the Portuguese ships lay at anchor for some time and their men came on shore. By a strange coincidence, the Sultan also arrived there about this time, and he attacked the party and killed a number of them. He plunged into the river after them on his horse and with great difficulty brought it back to the shore. The admiral (*Amir-ul-Bahr*) of Broach now came up with his ships and destroyed some of the enemy's vessels, and the rest escaped towards Div. The Sultan then went to Broach where he dismissed its incompetent *Amir* telling him that 'he was a cowardly fox and that any one who had given him the name of Nahar—an Indian word for a lion—had made a mistake.'[3]

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the rauza mentioned above, a caravansarai and a beautiful mosque. In the time of Momin Khan II, the son of Najm-ud-Daulah, when the Marathas laid siege to the city, the people, fearing lest the invaders should use this mosque as a base for their operations, filled it with fuel and set fire to it. Only the back wall of the masjid is left, but judging from it, the building must have been of excellent workmanship. Afzal Khan, the *Shahid* or martyr, was long venerated as a saint and people visited his tomb. His brother, Malik Zain-ud-din, a Sufi of renown, is also buried in another tomb by the side of the vazir. Another mosque, within the city walls at Jamalpur, was also built by Afzal Khan, and stands near the tomb of Sardar Khan. (*Mirat-i-Ahmadi Supplement*, translated by Nawab Ali and Seddon, p. 78.)

1. *Arabic History of Gujarat*, op. cit., 285.

2. Bhadbhut is a small village situated on the north bank of the Narbada, about eight miles from the town of Broach. It is a place of Hindu pilgrimage where a fair is held in honour of Mahadeo under the name of Bhādeshwar. The fair comes on when Bhadarvo (Aug.-Sep.) is an intercalary month—an event that happens once in every 19 or 20 years (*Bombay Gazetteer*, Vol. II, Surat and Broach, 550).

3. *Arabic History of Gujarat*, loc. cit., 286.

In this same year the Sultan decided to make yet another war on the Firangis and to recover Div. The Portuguese were much concerned at hearing these news, and an envoy came to the court from the Viceroy Saheb of Goa with a present valued at several *mans* of gold, and expressed regret for past behaviour with promise of making amends in the future to the entire satisfaction of the Sultan. The latter, however, was firm about carrying through his resolution, and would neither allow the envoy to wait upon him nor accept the presents which he brought.[1] At this time news arrived from Delhi that Sajawal Khan had captured Mandu on behalf of Sher Shah Sur who was intending an invasion of Gujarat.[2] The nobles of the Kingdom held a conference to discuss the situation and came to the conclusion that Sher Shah was all-powerful in India (*Sahib-ul-Hind*) and that it was more imperative to oppose his designs than to be occupied with other entanglements. It was, therefore, desirable to conclude a treaty of peace with the Portuguese and thus to relieve themselves of this danger, after which they could discuss the measures to be taken against the Delhi menace.[3]

Mahmud III resolves to renew the war: envoy from the Viceroy of Goa.

The Portuguese envoy was, therefore, permitted to wait on the Sultan and to offer his presents, and an agreement was concluded on the following terms between the two powers. The harbour of Div was to belong to the King and the Firangis were not to interfere with the royal ships. The fort of Div was to remain in the possession of the Protuguese and they were entitled to keep one-half of the duties levied upon all trading vessels. In case of attack, the garrison of the castle were to place themselves under the orders of the Gujarat Sultan.[4] Nasir Habash Khan, an Abyssinian noble at the Gujarat court, who was formerly the head of the police at Ahmadabad, was now sent to Div as its Amir or governor and he proved himself a capable officer and the Firangis and others were held in check. During his tenure of office the city of Div flourished and its inhabitants felt secure. In H. 955 (A. D. 1548), Div could boast of 100 sea-going vessels, and had 6,000 powerful troops with a cavalcade of 4,000. The prosperity of the place may also be judged from the fact, related by some of its inhabitants, that more than five hundred employees of the dealers in meat used to be present in the slaughter-house every morning.[5]

Treaty of peace between the Sultan and the Portuguese.

1. *Arabic History of Gujarat,* op. cit., p. 286.

2. There is some discrepancy here, for Sher Shah Afghan died in H. 952 *i. e.,* A. D. 1545.

3-5. *Arabic History of Gujarat,* op. cit., 287.

CHAPTER II

PORTUGUESE ACCOUNT OF THE SIEGE OF DIV UP TO THE ARRIVAL OF D. JOAO DE CASTRO

The great historians of Portuguese India—Barros and his *Decadas.*

We now turn to summarise critically, in this and the two succeeding chapters, the foreign accounts relating to the operations at Div, as also to other memorable episodes associated with that event, which have been handed down to us in elaborate detail by the Portuguese chroniclers. In the course of the 16th century a pleiad of distinguished writers arose in Portugal to narrate the great discoveries and conquests of their countrymen in Asia, Africa and the ocean. Many of them saw the achievements they relate and were inspired by patriotism to record them. Of these, João de Barros (1496-1570), called the Portuguese Livy, may be said to have been the first great historian of his country. His *Decadas da Asia* undoubtedly influenced the epic poet Camoens, and together the two writers fixed the Portuguese literary language, the one by his prose, the other by his verse. But Barros was able to publish only three of his 'Decades' during his lifetime. His narrative, therefore, misses the period with which we are concerned.

Diogo de Couto.

Diogo de Couto, a contemporary of Barros, a more critical historian, and a clear and correct stylist, continued this great work in nine more 'Decades,' and as thus completed it may be regarded as the noblest historical monument of the century.[1] It is in the sixth Decade of his *Asia* that Couto gives us the history of D. João de Castro's time and the operations at Div. But this very Decade, so valuable for our purpose, has suffered some mutilation, for it was burnt after printing, but before publication, as the account did not find favour with certain people. We learn that Couto's brother-in-law, a priest named Fr. A. de Trinidade, touched up the sixth Decade previous to reprinting the same in the form we now have it in order to please certain persons who did not like the unvarnished narrative of Couto.[2]

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1. The best known edition is *Da Asia* by João de Barros and Diogo de Couto, published at Lisbon (1778-88) in 24 small volumes. The Index Volume includes a Life of Barros by the historian Manoel Severim de Faria.

2. Whiteway, R. S., *Rise of the Portuguese Power in India*, pp. XI, 302.

Supplementing the *Decadas*, we have the works of two other Portuguese historians of the 16th century. The first of these, Fernao Lopes de Castanheda, wrote, after twenty years of investigations at Goa, his famous *Historia do descobrimento e Conquista da India* (1552-54 and 1561). This work, which is mainly based on original documents, is very valuable indeed, being a history in 8 books, ending with the term of Nuno da Cunha. We learn from Couto that Castanheda completed his history in 10 books, but that, at the request of some fidalgoes who were in the second siege of Div, and who were dissatisfied with the straightforward narrative, the king of Portugal had the last two books destroyed.[1] Like the preceding writer, Gaspar Correa lived long years in India and embodied his intimate knowledge of the country in the picturesque prose of his *Lendas da India*, which embraces the events of the years 1497 to 1550.

The works of Castanheda and Gaspar Correa.

During the 17th century, Manoel Faria e Souza, a voluminous writer on Portuguese history and the commentator of Camoens, wrote in Spanish his *Asia Portugueza*, much of which is little more than a compilation from Barros and Couto. But more relevant to our purpose was the production of the grandiloquent biography entitled *Vida de D. João de Castro* (1651) by Jacinto Freire de Andrade who thought to picture and exalt therein the last of the great governors of Portuguese India, during whose term of office the second siege of Div by the Muslims came about. This governor played personally, and through his sons, a very important part in the war and subsequently celebrated at Goa in 1547 a great 'triumph' for the victory. That De Andrade's *Life* of the governor should have been translated into English by Sir Peter Wyche[2] in 1664, a few years after its publication, shows that it must have enjoyed a considerable measure of popularity in its day, especially when we consider that hardly any of the great histories in Portuguese written in the 16th century has been rendered

De Andrade's *Life of D. João de Castro.*

1. Couto, Dec. IV, Lib. 5, Cap. 1; Whiteway, R. S., op. cit., 301.

2. Sir Peter Wyche (1628-1699) was a scion of a distinguished cavalier family under Charles I and Charles II, his father, bearing the same name and title, being British ambassador at Constantinople under Charles I. He was knighted by Charles II at the Hague in May, 1660, and was declared one of the Fellows of the Royal Society upon its foundation by charter in 1662. In 1669 he was sent as envoy extraordinary to Russia. Wyche executed two capable translations from the Portuguese, one of which was "The Life of Dom John de Castro, the Fourth Viceroy of India." This was dedicated to Queen Catherine, the consort of Charles II, prefaced by a brief sketch of Portuguese history by Wyche, and licensed for the press by Henry Bennett on 12 Aug. 1663. A second edition, also in folio, appeared in 1693. (*Dict. of National Biography*, Vol. LXIII, p. 194.)

into English. The biography covers about 270 folio pages, and we have given full references to the very rare and valuable English translation of 1664 in this survey. It cannot, however, be denied that de Andrade's style is stilted and bombastic and that he is an uncritical panegyrist not only of his hero's actions but also of the atrocities committed by his countrymen against the civil populations of the coast towns of Gujarat. His method of dealing with his authorities is also often open to criticism.[1] But the work is very useful as containing the most elaborate account of all the historical events connected with our subject.[2]

Plan of this chapter.

The memorable military operations which began at Div in April 1546, and which lasted for full eight months till November of the same year, are, as mentioned above, described at elaborate length by our Portuguese authorities. There is little doubt that Safar and his successors were brave and eminent generals and that they were assisted by military engineers who were experts in the art of siege operations. We do not propose to enter into any detailed account of these operations, of assaults and defence, of mining and counter-mining, of breaches and repairs. But we shall describe some of the most outstanding episodes of this heroic struggle and also refer to the efforts made by D. João de Castro, the Governor at Goa, to send succour to the beleagured garrison, in order to enable it to hold out until he came up in person with all the resources of Portuguese India behind him as soon as the season of tempests had ended.

Arguments for the war.

The Portuguese writers represent Khwaja Safar as delivering an impassioned speech before the Sultan and the assembled nobles at the Gujarat court in favour of war against the foreign power which had usurped sovereign authority over the island of Div. The various reasons urged by him in support of this policy are of great historical interest. Foremost among these was revenge for the death of Sultan Bahadur who had been deprived of his life by the Portuguese 'to the great scandal of other kings and no less outrage of his subjects, enjoying as inheritance a place (Div) which by so heinous an offence they had made their own, lately strangers, now patrons.' Safar next dilated upon the long series of Portuguese conquests in India, how 'with one

1. De Andrade's *Vida* edited by Fr. Franscisco de S. Luiz, published in 1835 by the Royal Lisbon academy, p. 387.

2. Mr. R. S. Whiteway, in his *Rise of the Portuguese Power in India*, says (p. 301) that D. João de Castro was 'unfortunate in his biographer,' and that 'his much vaunted life by Andrade is stilted, bombastic and untrustworthy'. Bombastic and stilted in style the work certainly is, but to say that it is, therefore, untrustworthy, is too sweeping a statement.

arm in Asia and the other in the West' they strove to grasp the world, though it was impossible for so small a kingdom to maintain for long so scattered an Empire. The Portuguese, he declared, had in India many Princes under them but not one friend, and all of them did homage to the strangers whom they dared not offend. All these Princes would hasten to join Sultan Mahmud as soon as he took the field against the common enemy of all. Lastly, this brilliant renegade urged the possibility of the Grand Signor at Constantinople seconding the armies of the Sultan of Gujarat in order to avenge his humiliation and losses in the earlier expedition against Div.[1]

Strength of the Gujarat army and artillery.

The siege operations began in April 1546 when Khwaja Safar entered the city of Div with 8,000 men, and from this day the Fort was cut off from all provisions by land while the storms of the approaching monsoon were soon to prevent all succour reaching it by sea. Besides his troops, Safar had a formidable park of artillery, consisting of sixty large pieces of cannon, including eighteen basilisks, for the operations of the siege which was to prove a very protracted one. A large part of his army consisted of Turkish mercenaries, and of these over a thousand were the famous Janissaries, men on special pay who had at this period the reputation of being the best soldiers in Europe. Safar showed himself a born soldier by the skill with which he made his dispositions, planted his batteries, opened his trenches and formed his squadrons. He set himself at once to the work of building up a formidable wall between the Fort and the city which had been pulled down by the Portuguese. In a speech to his army he pointed out the small numbers of the garrison and their lack of provisions and munitions, while he specially exhorted the Turkish soldiers to take revenge for the damage which the Portuguese had inflicted on the Grand Signor's galleys at the earlier siege of the same fortress.

Relief brought by Dom Fernando, the Governor's son, May 18, 1546.

After the siege had been in progress for a month, the Captain of the Fort, D. João de Mascarenhas, was beginning to get not a little anxious owing to the breaches in the walls and the shortage of provisions and munitions, when the first relief sent by the Governor from Goa arrived in the shape of nine vessels in which came Dom Fernando de Castro, the second son of the Governor, a young man of nineteen but full of courage. The Captain met him on the steps of the fortress

1. *The Life of Dom John de Castro*, by Jacinto Freire de Andrada, trans. from the Portuguese into English by Sir Peter Wyche, Kt., London, 1664, pp. 57-63.

and took him in his arms. By virtue of his father's position he offered him his own house to stay in, but the brave young noble would not accept this declaring that the part of the fortress exposed to the greatest danger should be his chamber. The fighting force was now raised to 400 men.[1]

Sultan Mahmud III arrives at Div with his Court.

Meanwhile, the incessant battering from the guns continued under Safar's directions who did not scruple to use the bodies of those of his men who were killed to fill up the ditch which surrounded the Fort, partly with the object of covering his losses which now began to be known in the army. Believing that the time for taking the Fort by assault was near, Safar invited Sultan Mahmud III, who was at Champaner, to come to the camp, so that he might place the fortress in his hands. The Sultan arrived with most of his court and a force of ten thousand horse. But, soon after, a random bullet from the Fort killed a Muslim in the Sultan's tent as he was discoursing with his sovereign. This being taken as a bad omen, Mahmud left the tent and the camp and retired to his pleasure house at a place which is mentioned as 'Melique' on the island of Div. He appointed a brave Abyssinian nobleman named Jhujhar Khan to assist Safar in the operations.[2]

The bravery of the Portuguese women in the Fort.

One of the most interesting features of the last siege of Div by the Gujarat armies was the part played by the Portuguese women of the garrison in the work of defence and in sharing with the men the hardships and dangers of the blockade. They showed extraordinary courage, helping to bring up materials for closing up the breaches, going up to the walls without fear, 'stumbling over lances, swords and bullets, mastering their nature and their sex as if they wore men's hearts in disguise.' There were even some who put on arms and braved the enemy. Among these one named Isabel Fernandez made herself specially prominent by her daring, and the Portuguese writers describe her as 'the Old Woman of Div.' This great matron spent part of her resources in junkets and regallos with which in the height of the siege she fed the soldiers, animating them to action by arguments above the courage and judgment of a woman.[3]

Death of Safar by a cannon-ball.

While actively supervising the trenches and the filling in of the ditch, Safar was killed, on 24 June 1546, by a cannon-ball from the Fort which took off his head while he stood in the midst of a company of Turks. With deep laments his army carried out the funeral ceremonies, and by his son's orders his body was conveyed to Surat to be interred there,

1. *The Life of Dom John de Castro*, op. cit., 83, 85.
2. Ibid., 86–88; Couto, Dec. 6, Lib. 2, Cap. 1.
3. Ibid., 89-90; Couto, Dec. 6, Lib. 2, Cap. 2.

for he was governor of that city.[1] Thus perished one of the greatest generals in the later history of the Gujarat Sultanate. Though often described as a Turk, he was by birth a European and a Christian and was familiar with the art of war as practised in the West.[2]

His son Muharram (Rumi Khan) succeeds in command.

Safar's second son Muharram, described both in the *Arabic History* and by the Portuguese writers under the name of Rumi Khan, succeeded his father in the command of the armies of Gujarat investing the Fort of Div, and he swore to avenge his father's death.[3] He pushed forward the operations with even more zeal and efficiency than his father had done. The ditch round the fortress having been filled up at six different places, and the battlements reduced to ruins by the incessant cannonade, Rumi Khan proceeded to deliver, with the help of his Turkish troops, and seconded by Jhujhar Khan, a succession of brilliant assaults against the bastions, all of which were heroically repelled by the ever-diminishing garrison. The first of these series of assaults took place on 19 July 1546.

The Turks enter the fort near St. James's Church.

During the second of these assaults, taking advantage of the fact that the attention of the whole garrison was diverted to the St. Thomas bastion, which was in danger of being lost, Jhujhar Khan invested the Curtain which he found undefended, though nature had made it strong by the craggy rock on which it stood. Under his direction, a hundred Turks with scaling ladders succeeded in reaching the Fort unseen near the Church of St. James. They also entered some of the houses, and took the women by surprise. But one of these, with manly courage, took up a spear, and going to a house where the Turks had gathered, forced the man who was acting as sentinel to retire inside at the point of her lance, after which she locked the door against the Turks and stood on guard. The women living round about were seized with fear and their cries of 'Turks in the Fortress' brought up D. João Mascarenhas to the scene, who ordered a soldier to bring over troops from the works where the enemy was not pressing. Proceeding to the house where the Turks were locked up, he threw a pan of powder among them, and then, with four others, he set upon them and pressed them so hard that they had perforce to

1. Danvers, *The Portuguese in India*, I, 470.

2. *The Life of Dom John de Castro*, op. cit, 92-3 ; *Arabic History of Gujarat*, op. cit., II, p. XXXVIII.

3. Rumi Khan, knowing that the battlements were in ruins and the garrison worn out by duty, sickness and wounds, sent a Portuguese offering honourable terms of peace to the Captain of the Fort, promising, if the garrison surrendered, to spare their lives and to give them ships for passage. The Commander, however, sent a defiant answer.

throw themselves down the rock. The Captain next proceeded to dislodge a number of the enemy who had taken up their post on the roof of St. James's Church.[1]

This general assault lasted for four hours. The dead at the base of the bastion of St. Thomas were so many that there was not enough ground for them: but their bodies made the scaling of the wall easier. The valiant Jhujhar Khan, who had come up to this side after the failure of his attempt at the Curtain, was now killed by a bullet from the Fort. This was the second great commander lost by the enemy after the siege commenced, and Rumi Khan on learning the news sounded a retirement and ordered the body of the dead general to be brought off.[2] It appears to have been subsequently removed and buried in the sacred grounds at Sarkhej near Ahmadabad, for the author of the *Arabic History* says that the tomb of Bilal Habashi, entitled Jhujhar Khan, is situated there.[3]

Death of Jhujhar Khan.

We shall now turn to relate the efforts made by the Governor Dom João de Castro at Goa to send adequate relief to the fort at Div, for he had been receiving letters and despatches overland about the great straights under which the garrison had to maintain its defence.[4] Postponing to a later date, in the interest of the State, his own eager desire to go in person to raise the siege, he equipped and despatched, about the end of July, two fleets. D. Francisco de Menezes, a commander of great fame, was sent first with seven ships. Three days later, the second fleet left under D. Alvaro de Castro, the eldest son of the Governor, and consisting of nineteen ships each of which was under the command of a capable Portuguese officer. The fact that the Governor, subduing his natural love and affection, had hazarded the lives of both his sons in this perilous warfare induced a large number of soldiers and captains, many of whom were exempted from service by their years, to offer themselves for the enterprize. Thus a large number of the Portuguese nobility at Goa left the place for maintaining the honour of the nation.[5]

Dom J. de Castro despatches two fleets from Goa in July.

1. *The Life of Dom John de Castro*, op. cit., 103-5.

2. Ibid., 105.

3. *Arabic History of Gujarat*, Vol. II, p. 432.

4. On the plain near Goa, the Governor erected, from drawings supplied by the Captain, a copy of the enemy's works at Div, and his soldiers were exercised in sham fights in assaulting them. (Couto, *Decadas*, VI, 3, 9, quoted by Whiteway, *The Rise of the Portuguese Power in India*, 311-n.)

5. *The Life of Dom John de Castro*, op. cit., 107-8.

De Castro next busied himself with making arrangements for the fleet with which he himself proposed to go north after the rains were over. The treasury was in a bad way and he had to secure the necessary funds on his personal credit. The matrons and maids of Chaul,[1] fired by his generous spirit, and 'with a liberality above women,' presented him with all the jewels and ornaments which they wore without either asking or obligation for return. 'We read not' says the biographer, 'in the annals of the Caesars a braver action of the Roman ladies'. A lady from the same town residing at Goa sent the Governor a box with her jewels with an assurance that 'the jewels of Chaul alone were sufficient for ten years to continue the war'.[2] The incident helps to illustrate the wealth and prosperity of this once famous seaport on the western coast.

The women of Chaul present their gold and jewels.

The state of affairs within the Fort, in spite of the successful defence which was maintained by the highest display of personal valour, may be realised from the fact that the garrison had no more powder left except what could be made every day and that too ill-dried, a want which the Muslims soon began to know about. Besides, famine conditions were prevailing owing to the exhaustion of provisions: the food being either used up or spoiled in the magazines rendered roofless by the enemy's fire. The sick were fed on crows instead of hens, these birds being killed by the soldiers as they came to feed on the dead bodies and by them sold at exorbitant rates. In fact, scarcity had reached such a height that they spared not dogs, cats and such other food which is generally regarded as 'unclean and unwholesome'.[3]

The garrison faced with starvation.

Rumi Khan (Khwaja Muharram), after the failure of several general assaults, resorted to new strategy by the advice of a Turkish engineer from Dalmatia, and began to lay a mine with great secrecy under the St. Thomas bastion. At the same time, the garrison was given to understand that the enemy had orders to abandon the Fort after delivering a last general assault. D. Fernando de Castro, though laid up in bed with fever, rose up on hearing of the contemplated attack and putting on his armour proceeded to the

The enemy spring a mine under St. Thomas' bastion, Aug. 10, 1546.

1. Chaul (or Revadanda) is a town in the Alibag *taluka* of the Kolaba District in the Bombay Presidency, situated on the coast about 30 miles south of Bombay, and on the right bank of the Kundalika river, or Roha Creek. It is a place of great antiquity. The Portuguese established a factory here in 1516.

2. *The Life of Dom John de Castro*, op. cit., 109.

3. Ibid., 118.

bastion of which he was in charge. It was the day of the feast of St. Lawrence, dedicated by his happy martyrdom to fiery trials. On August 10, 1546, one of the most fateful days during the whole siege, the Gujarat army disposed itself about the fortress and all the companies took their allotted posts and planted their ladders. When the time for springing the mine came, the whole army on a given signal retired, and the same fear, equal and sudden in all, betrayed the plot. D. Mascarenhas shouted out to his men to leave the bastion so that the mine might explode without hurting the defenders. All left their posts at this order except one, Diogo de Reynoso, whose bravery outwent his discipline, and who kept his place scornfully calling those who left cowards. This had the effect of bringing them all back to the tower to meet their doom. The mine took fire with a tremendous report and the stout defenders lay dead in their places.[1]

D. Fernando and 60 others perish.

In this disaster perished D. Fernando, the second son of the Governor, at the early age of nineteen, 'raised from a sickness nature might have passed over but courage made it mortal.' Among others who were blown up was Diogo de Reynoso whose rash conduct was responsible for the disaster. In all, sixty Portuguese soldiers and captains lost their lives while thirteen more were wounded or deformed by the fire. The explosion was so great that the stones of the fortress blown up by its violence killed a great many in the enemy's camp. When the fortress was clear of the smoke, and the bastion laid in ruins, Rumi Khan ordered 500 of his Turks to the assault. Now was seen the unusual spectacle of only five Portuguese soldiers sustaining the attack against such overwhelming odds. The Captain soon came to their help with fifteen more, and John Coelho, the Chaplain of the Fort, with his crucifix in his hand, took up his stand in the breach. The report that the work was lost soon brought up others from their posts and all of them combined made up a force just able to keep at bay a vast army. The women too brought up lances, bullets and pots of powder, while one of them, the Isabel Fernandes mentioned before, "with a bill[2] in her hand animated the men with her example and her words, crying aloud, 'Fight for your God, fight for your King, Cavaliers of Christ, for He is on your side'." The Janissaries fought as never before, but the heroic nature of the defence baffled all their exertions, and as the day was declining

1. *The Life of Dom John de Castro*, op. cit., 109-22.

2. A 'bill' was a weapon of infantry in the 15th and 16th centuries consisting of a broad, heavy, double-edged, hook-shaped blade, having a short pike at the back and another at the top, and attached to the end of a long staff.

their general sounded a retreat. 'Of the great things the Portuguese did that day,' says our biographer in his stilted style, 'let the whole East speak; I believe every stone of famous Dio will be for them a silent epitaph.'[1]

After the enemy had retired, D. Mascarenhas gave orders for the burial of the dead who had perished in the explosion caused by the mine. It was but removing them from one grave to another, since for lack of time and space they were all buried together without any funeral honours. 'Yet rest they,' says our magniloquent biographer, 'in so poor a grave, more missed by their country than those who in alabaster urns have left of inglorious lives an idle memory.' D. Fernando de Castro, however, was laid in a depository by himself, so that if his father should wish to carry his bones to another place, he might give him a more stately but not more glorious monument. The Captain of the Fort, with pious earth, covered up his companions and then fell upon repairing the breaches in the walls, helped by the women who had little time to weep for their sons or husbands whom they had seen expiring before their eyes, and had themselves buried, 'by unheard of examples smothering the inclinations of nature.'[2]

Burial of those who perished in the explosion.

While these events were taking place at Div, the two fleets which had set out from Goa at the end of July, after being tossed about the stormy seas, at last reached Bassein shattered and torn. Further progress up the gulf to the north was impossible owing to the tempests. But though the main fleet under D. Alvaro was kept inactive at this port, some of his adventurous captains were not prevented from venturing in small boats to proceed to Div to bring some news. Among these famous names were those of Antonio Moniz Barretto, Garcia Rodrigues de Tavora and Luis deMello. They brought but poor relief to the garrison, but their advent immensely heartened the decimated forces in the Fort, who were also cheered up by the report that D. Alvaro was near them with a large fleet and provisions. The details of the narrow escapes of these captains from being drowned in

Dom Alvaro's fleet reaches Bassein.

1. *The Life of Dom John de Castro*, op. cit., 123-25; Couto, Dec. 6, Lib. 2, Cap. 10. Among the five valiant soldiers who kept the Tower after the explosion of the mine, was 'Mastre' John, the surgeon of the garrison. He alone, however, of the five died, torn in pieces by his many wounds, unwilling to leave the fight though pressed to do so. His wife, Isabel Madeira, bound up his wounds, and, after burying him with her own hands and with few tears, returned to work in the trenches with the other matrons.

2. Ibid., 125.

their little boats on their perilous voyage are given at length by the Portuguese writers.[1]

Dom Alvaro reaches Div, Aug. 29, 1546.

After a time, Dom Alvaro left the fort of Bassein with his fleet determined to proceed to Div, but soon his vessels, being overloaded with munitions and provisions, were at the mercy of the heavy seas and were scattered about till most of them were driven into the harbour of Agashi.[2] Refitting them, Alvaro ventured to sea again and arrived at the Fort of Div with forty ships, their streamers flying, and saluted the fortress with all his guns. The Captain had the gates of the fort opened to give him and his companions a warm reception. Though the son of the Governor and himself Admiral at sea, Dom Alvaro produced a letter from his father to Dom J. Mascarenhas, to the effect that he had sent his son to take orders from the Commander by virtue of the high honour he had acquired during the siege. Alvaro found the fortress razed and open to the enemy, the walls and bastions being heaps of rubbish, and the garrison maintaining an inner line of defence and at its last gasp. His arrival with such large reinforcements was the turning point in the history of the siege.[3]

Mutinous decision of the Portuguese soldiers.

There were now six hundred men in the fortress, all soldiers and captains of repute, and their spirits were high. A party of Alvaro's soldiers, preferring to sally out and fight the enemy than to remain cooped up and be burnt to death by the mines, resolved to give open battle to the Muslims. In vain did their officers try to dissuade them from this mutinous action, reminding them of their duty to obey their generals and of their honour to serve the King. But the advice as well as the orders fell on deaf ears. Finding that the soldiers held to their resolution, and in order to avoid a disaster which might prove fatal to the fortress, both the Captain of the Fort and Dom Alvaro, as also other gentlemen,

1. *The Life of Dom John de Castro*, op. cit., 127-30; 138-40. In the renewed assaults by the Muslims on the Fort these Captains, who had lately arrived there, gave eminent help "showing in the extremities both by land and sea the same gallantry." We also find the name of another great Gujarat general mentioned, viz., that of Mujahid Khan who came with a large reinforcement. An attempt made by the Muslims to break the great Cistern in the fortress (seen in the map), which supplied the garrison with water, was also frustrated. (Ibid., p. 144)

2. Agashi is a port and town in the Bassein *taluka* of the Thana District, Bombay, situated ten miles north of Bassein and 3 miles west by road from Virar on the B. B. & C. I. Ry. It was a place of some importance in the early part of the 16th century, with a considerable timber and ship-building trade. It was twice sacked by the Portuguese, in 1530 and in 1531, and on the first occasion as many as 300 Gujarat vessels are said to have been taken. (*Imp. Gazr.* V. 71).

3. Ibid., 148-50; Couto, Dec. 6, Lib. 3, Cap. 1.

decided to go with the soldiers in order to avert greater mischief, 'the commanders by a new discipline obeying and the soldiers commanding'.[1]

Disastrous result of their action, Sept. 1, 1546.

Dom João Mascarenhas left a hundred men to maintain the Fort, and sallied out with five hundred troops, dividing them into three battalions, one of which he kept under his charge and the other two were placed under Alvaro de Castro and Francisco de Menezes. It was a foolhardy venture in the face of a vast army of perhaps 20,000 men commanded by capable Muslim generals. The attempt ended, as was to be expected, in disaster, for the effort to scale the new wall built by the enemy was an impossibility. The Commander at last rallied the scattered forces and brought them over to the fortress. The Portuguese lost 35 men with about a hundred wounded. Dom Alvaro distinguished himself by his immense courage in scaling the wall whence he was thrown down with a blow from a stone. He was picked up speechless and was in danger of his life for three days after which he began to rêcover. Francisco de Menezes and Louis de Mello were shot through by bullets.[2]

Rumi Khan builds a new city to celebrate the victory.

The success which the unruly obstinacy of the Portuguese soldiers had placed in Rumi Khan's hands was magnified by him into a great victory which being reported as such to the Sultan was celebrated at court with public rejoicings. Moreover, he now began to build a new city on the island of Div either to put heart into his men or to show his own confidence in final victory. He planned palaces therein of stately grandeur for himself and set out quarters for his officers. The news of this expensive "fabrick" travelled into the other kingdoms beyond Gujarat, and a false report that the Portuguese had surrendered the fortress became current, and even found its way to Goa, where the rumour was listened to with fear and silence, and, though unsubstantiated, did not fail to reach the Governor's ears.[3]

The Governor at Goa receives news that the Fort held out.

Dom João de Castro was at last relieved from his concern about the events at Div by the arrival at the bar of Goa of the ship which had carried Dom Alvaro in July. Her flying streamers and joyful salute indicated from afar the nature of the news she brought, and soon the greater part of the citizens ran to the seaside to enquire after their kindred and their friends. The captain of the vessel was carried to the Governor's palace where he found him seated with the Bishop of Goa and the head of the Franciscan Order. The first question from Dom João was to enquire whether the fortress still held out for the

1. *The Life of Dom John de Castro*, op. cit., 151-2.
2. Ibid., 153-55; Couto, Dec. 6, Lib. 3, Cap. 5 and 6.
3. Ibid., 156-7.

King, his master. To this the captain answered that it did and would do so, whereupon 'the Governor falling on his knees with his eyes to heaven gave God thanks, not without shedding some tears, witness of his piety towards God and his zeal for his Prince, and receiving presently his letters, he heard the death of his son Dom Fernando, which he received with so great constancy as those about him perceived no alteration in his words or countenance, as if to appear a father had been weakness, and to have the common affections of a man dishonour. He thanked the captain, and sent him to cheer the city with the news: then retired and in private wept for his son'.[1]

1. *The Life of Dom John de Castro*, op. cit., 158-59; Couto, Dec. 6, Lib. 3, Cap. 7.

CHAPTER III

PORTUGUESE "REIGN OF TERROR" ON THE GUJARAT COAST

The Governor summons a full Council at Goa.

Dom João de Castro, at the end of the rains, summoned at Goa a Council to which he invited the 'Ecclesiastical and Civil Government' of the city, as also the gentlemen and soldiers of eminence, in order to place before them his resolution of proceeding to Div, with the whole might of the Portuguese State in India behind him, to raise the siege and to chastise the King of Gujarat. His object was to secure public approval for his design so as more successfully to carry it into execution. Various opinions were expressed by those present, but the most emphatic opposition to it was made by Diogo de Almeyda Freire, Commander-in-Chief at Goa, a man whose judgment had been ripened by age and experience in wars.[1]

The enterprise opposed by the Commander-in-Chief.

Dom Diogo made a brilliant oration pointing out that His Excellency the Governor had brought together in his fleet the whole available strength of the 'State' in India and yet they could reckon only two thousand Portuguese as their force. With this it was intended to frighten the nations of India, not realising that one victory would add but little to their reputation, while only one loss would be their ruin. The fortress of Div, he urged, had already been relieved. Was it prudence to take the risk of going to fight against the Turks who were equal to them in arms and discipline while exceeding them in numbers? To these and other arguments Dom João gave an emphatic rejoinder for he was not to be moved from his firm resolution. He urged that no ruling nation could content itself with a defensive war against her inferiors and that the respect which the Muslims had for them would be at an end when they knew that they could put up with an injury; that if the Portuguese were content with rebuilding their Fort, the enemy would come again and aim another blow; that 'Reputation was the soul of Empire'; and that he would not suffer the first weakness of the Portuguese arms in the East to appear in his time. He concluded by asserting his resolve to fight, 'the blame would be his, every one should have a share in the victory.'[2]

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1. *The Life of Dom John de Castro*, op. cit., 162-65. 2. Ibid., 162-65.

On 17 October, 1546, the Governor, after delivering over the charge of the city to the Bishop Dom João de Albuquerque and to the Commander-in-Chief, set sail from Goa directly for Bassein, 'making it a point of honour that the Governor of India should not be one day besieged in Dio, but with Caesar's fortune, come, see and overcome.' The fleet with which he started consisted of twelve gallions, of which the 'Admiral' was *St. Denis*, on which was the Governor. Besides these large vessels there were sixty others with oars. After six days the Governor reached Bassein, where Dom Jeronymo de Menezes, his brother-in-law, was commander of the fortress. The latter came to meet Dom João on board, and the two comforted each other in the loss of a brother and a son.[1]

Dom Castro arrives at Bassein.

While anchored at Bassein awaiting recruits and provisions, the Governor commissioned Dom Manuel de Lima[2] with six light ships to sail about the Gulf of Cambay and its coasts to capture the ships trading with the enemy. In a few days he took some sixty vessels carrying provisions, and the bodies of the Muslims whom he killed he ordered to be mangled and set them afloat at the mouths of the rivers so that the current might carry them inland where they might be seen with horror as examples of Portuguese revenge. After accomplishing his commission, Manuel de Lima returned to Bassein with three score Muslims hanging at the yard arms, 'a sight which sacrificed more to vengeance than humanity.' Gratified at these preludes to the war he had undertaken, the Governor sent him out again with thirty ships with orders to put to fire and sword all the coast of Gujarat.

Manuel de Lima terrorises the Gulf of Cambay.

Manuel de Lima, thereupon, set sail again and went by night to the mouth of the Tapti, which he entered with the tide, and came in sight of a place (Magdala) which was inhabited by the Abyssinians and had its name from them. The Captain went on shore with his men, and the Muslims of the place fled after a slight resistance, many being cut off in their flight. The slaughter was great, 'the soldiers' sword sparing neither sex nor age.' Dom Manuel ordered his men to fire the houses, burning down the town and all its property. Only one man, whose hands were ordered to be cut off, was left alive to carry the news of this atrocious victory.[3]

Magdala on the Tapti burnt and its colony butchered.

1. *The Life of Dom John de Castro*, op. cit., 167-8; Couto, Dec. 6, Lib. 3, Cap. 9.

2. Manuel de Lima had been sent out by the King to take command of the Fort of Hormuz. But, on his arrival at Goa, he was detained by the Governor who wanted him to accompany the fleet which he was preparing.

3. Ibid., 173-4; Couto, Dec. 6, Lib. 3, Cap. 9.

After this exploit, De Lima's fleet went out of the river, and coasting along for two days came in sight of the city of Hansot at the mouth of the Narbada, not far from Broach. It is described as famous for its proud buildings and wealthy inhabitants enriched by maritime commerce. The Muslims made a brave but ineffective stand for lack of discipline and organisation. Here again, Dom Manuel, 'more designing ruin than conquest, gave up the city to the flames. The cruelty outwent the destruction, for many Bramenish (? Brahman) young ladies, exempted from crime by their sex, from the sword by their faces, in colour and beauty not inferior to those of Europe, were not spared in the victory'. This was not all, for this buccaneer went about the coast destroying the towns and depopulating every place on which he fell 'as to seem not to be glutted with blood or victory,' and at last joined the Governor who with the whole fleet was stationed at an island named Dos Mortos.[1]

Hansot delivered to the flames and its women put to the sword.

Setting sail for Div, the Governor soon reached the place on Nov. 7, all his vessels gay with pendants and streamers. Those in the Fort, which was now practically razed to the ground, decorated it with colours, and the Commander ordered all the guns to be fired. Dom João de Castro held a council at sea with Garcia de Sa and other members and announced to them his resolution to take the offensive and to attack the enemy, for 'the Governor of India drew not his sword to defend but to chastise'. He only asked them to give their advice about the manner in which, they should fall upon the Muslims, the decision being kept a secret.[2] It was then ordered that all the men brought by the fleet should land very quietly in the silence of the night and enter the fortress, while music, trumpets and shooting from the ships should conceal the design from Rumi Khan. In the course of three nights

Arrival of Dom J. de Castro at Div, 7 Nov., 1546.

1. *The Life of Dom John de Castro*, op. cit., 174-5. Ilha dos Mortos, or Ilha de Bete, an island eight leagues to the east of Div (Danvers, *op. cit.*, II, 533.); probably the island of Shiyal Bet.

2. The Governor's plans were cleverly laid. The Gujarat army was to be kept under the impression that the great contingent of soldiers which came in his fleet was still on board the ships so that Rumi Khan's strength would be concentrated in that direction. On the day when the garrison was to sally forth from the Fort to give open battle, three rockets were to be fired from the fortress. At this signal the ships' boats were to row towards the shore where the enemy was, with drums and trumpets sounding, the boats bristling with lances to create the impression that the Portuguese soldiers were coming *en masse* by sea. The Governor's boat was to be specially prominent by its place, its royal flag and trappings. Thus Rumi Khan (Khwaja Muharram) and his army were to be diverted from the real direction of the danger. (Ibid., 177.)

this was effected and the men in the fleet all got into the Fort by ladders made of cords without being discovered.[1]

At daybreak on November 11, 1546, the day dedicated to the memory of Saint Martin, Bishop of Tours, the Governor, with the first light, came on the platform of the fortress attended by his General Staff and clad in white armour which added a great deal to his majesty. Mass was said at an open altar praying for victory from the God of Hosts. Dom Castro and the major part of the soldiers received the sacrament, while the Guardian of the Franciscans proclaimed a plenary indulgence to all those who died in the battle that was coming. After this the order was given that the gates of the fortress should be pulled down so that despair of any shelter should make the soldiers make a stand for victory both out of glory and of necessity. The Governor then gave a brief discourse, ending with the words: 'for me to encourage you to fight were to forget myself we were Portuguese'.[2]

The Governor solemnly prepares for the battle.

Outside the fortress the Governor made dispositions for the order of his troops. The vanguard was in charge of Dom John Mascarenhas, who claimed the greatest danger, and under him were placed five hundred Portuguese soldiers, six hundred Canarese and five hundred Nayers. Similarly, Dom Alvaro de Castro had the same number of Portuguese, and among these were the gentlemen and officers of his fleet. Dom Manuel de Lima had five hundred more. The rest were under the direct orders of the Governor and they formed the largest unit consisting of eight hundred Portuguese, the rest being men from Canara and Malabar.[3] Dom J. de Castro arranged to place 200 Canarese in the van of the army so that, should the enemy have laid any mines, they would be the victims. His officers, however, were indignant at this declaring that if the Canarese were placed in front of the Portuguese they would deserve the greater honour and glory. 'There is not one among us,' they said, 'who would not risk even seven lives and be to the forefront of the fray'. The Governor was pleased and decided to leave the Canarese behind.[4] His original idea, however, showing the little value he placed on the lives of his Indian troops, is little to his credit.

Disposition of his army.

1. *The Life of Dom John de Castro*, op. cit., 175-6; Couto, Dec. 6, Lib. 3, Cap. 10.

2. Ibid., 177-8. The Governor now ordered the signal to be given to the fleet by the firing of three rockets. Upon this the ships in the fleet took to their oars and discharged all their guns in the enemy's quarters. The smoke for some time hid the boats, and Rumi Khan, unaware of the real direction of the danger, charged them in order to hinder them from landing. (Ibid., 181.)

3. Ibid., 178.

4. Danvers, F. C., *The Portuguese in India*, I, 473.

The great battle of Div, which was fought out on the 11th November 1546, is memorable in the history of Gujarat as one of the most decisive in the annals of the province. It consisted of a series of separate engagements, the first fight being against the enemy's wall and their line of batteries. The Governor led his men in person, and before him Antonio de Casal, the Guardian of the Franciscan Order, carried aloft a crucifix. While scaling the wall at the first fight, a bullet broke one of his arms, but the brave monk continued at his post exhorting the Portuguese to die for their Saviour. The Captain of the Fort and Dom Alvaro together captured a bulwark on which they twice planted the Portuguese colours, which were as often cut down. In the end, however, with a rush the line of batteries was carried and they entered the enemy's works. Then followed a series of battles in which Rumi Khan and Jhujhar Khan made a stubborn resistance; but the Portuguese generals, though at times compelled to retire, again returned to the charge and with such fury that the Gujarat army was at last routed and driven into the city.[1]

The great battle of Div, Nov. 11, 1546.

The Battle of Div ranks among the most famous incidents connected with the Portuguese power in the East. The strength of the Gujarat army during the battle is variously estimated, but the lowest figure puts it at forty thousand. There is no doubt that the disparity in numbers between the two armies was immense, and 'in foreign histories we find the victory writ with more applause than in our own memorials,' says the biographer. The Governor received congratulations on the victory from the Princes of India who sent him embassies; the Chamber of Goa called him Duke; and, later on, the King, Dom John III of Portugal, honoured him with the title of Viceroy of India, he being the fourth Governor to receive this great honour.[2]

Reflections on the victory at Div.

After he had set aside the King's share of the booty, several colours, and forty large pieces of cannon, the victor delivered over the city of Div to plunder according to the barbarous practice of the age though he did not reserve for himself even the point of a lance, 'so greatly did he despise the riches of the East.' Five thousand of the enemy perished in the battle, among them being Rumi Khan, Ulugh Khan, Asad Khan, and other nobles of note. Six hundred were taken prisoners and they were reserved to honour the Triumph which was

The sack of the city and the losses of the Muslims.

1. Couto, Dec. 6, Lib. 4, Cap. 2.
2. *The Life of Dom John de Castro*, op. cit., 188.

some months later celebrated by the Governor at Goa with the greatest pomp and ceremonial as we shall relate. The Portuguese lost thirty among the dead and had three hundred of their numbers wounded.[1]

After a very short respite, the Governor set himself to the task of rebuilding the fortress of Div, but though this work was indispensable it was found that it was beyond the resources of the "State" which had been drained by the expenses of the long siege. Not disheartened by these difficulties, Dom João de Castro went about raising a new Fort on a fresh plan, for in the opinion of experts it was necessary to enlarge the area within the walls, to make these walls thicker and the bastions nearer, and to build the magazines in a dry place for storing ammunition and provisions so as to prevent them from being damaged by the moistness of the soil. But workmen and pioneers and stone-cutters had all to be brought and paid. As the Governor had neither plate nor jewels to serve this purpose, he was forced to try other pawns 'valuable by his honour not by their nature'. He commanded the bones of his son Dom Fernando to be dug up in order to send them as 'an unheard of pawn' to the city of Goa; but the body not having corrupted during so short an interval, Dom John cut off some hairs of his own beard and sending these as a pledge asked for a loan of twenty thousand Pardaos from the Chamber of Goa. 'His affection for his country,' says his biographer, 'finding him out a strange way, never lighted upon by those loyal Decios, Curtios and Fabios of whom Rome yet proud preserves their memory in the ruins of her Empire.'[2] The pawns were accompanied by a letter which we shall quote in full as illustrative of the manners, the ideals and the language of the age:

Project for rebuilding the Fort of Div.

"A letter writ from Dio by the Governor Dom João de Castro to the City of Goa

"Gentlemen, magistrates, judges, and people of the most honourable and always loyal city of Goa: I writ to you some days since by Simaon Alvarez, one of your citizens, the news of the victory God gave me against the commanders of the King of Cambay, and, that you might without any alloy enjoy the pleasure and satisfaction of the victory, I spoke not in my letter of the great streights and necessities I was in. But now I think fit no longer to dissemble, and to give you an account of the urgencies which are upon me, and to desire your assistance to supply and remedy things of so great moment as are now in my hands. For the fortress of Div is so beaten down to the ground as not one

1. *The Life of Dom John de Castro*, op. cit., 188-9.
2. Ibid., 189-90.

foot of the wall can serve again, so as 'tis not only necessary this summer to build it up again, but with such skill and in such a form as the King of Cambay may lose his hopes of being at any time able to take it.

" To this trouble is added another as great, or greater, to me incomparably above all others, which is the trouble and perplexity the Lasquerins put me to for their pay, which I have secur'd to 'em, else would they be all gone, and I should be left alone in the fortress, which would put me into no little danger, and consequently all India. For the commanders of the King of Cambay, with those men who are left of the defeat, quarter at Suna, two leagues from this fortress, and the King every day sends 'em horse and foot to increase their camp, as if they would return and try their fortune by giving another battail.

" Wherefore, I am in great want of a considerable sum of money, and, because it concerns the service of our Lord the King, and complies with your honour and loyalty, I earnestly beg of you to remember your old custom and great generosity, which oblig'd you (as good and loyal subjects) always to relieve the urgent necessities of his Majesty. And for the great and intimate affection I have for you all, you would lend me twenty thousand Pardaos, which as a gentleman I promise, and on the Holy Gospel swear, before a year's end to see you repaid, though I should be set upon by greater necessities and extremities than those by which I am at present environed.

" I commanded the taking up my son Dom Fernando, whom the Moors killed in this fortress (fighting for God and our Lord the King), to pawn to you his bones, but they were found so as 'twas not fit to take 'em out of the ground. By which I am without any other pawn, but part of my beard, which I here send you by Diogo Rodriguez de Azevedo, for as you know, I have neither gold, plate, household-stuff, or any thing of value to secure your estate, only a plain and naked truth given me by God Almighty.

" But that you may more certainly rely on your payment, and it may not be thought by some that (what hath at other times fallen out) some intervening accident may keep you from it, I here send you an order for the Treasurer of Goa to be paying you out of the tax for the horse, engaging all can be made of it, till you are re-imburst; for the manner of the paying it you are to fix it with him. Excuse me for not affecting words to heighten to you my extremities, being, from what I have said before, firmly

persuaded that you will in this conjucture do what you can, and above your abilities, without any other mediation than your accustomed nobleness and our reciprocal affection. I recommend myself, gentlemen, to your goodness. Dated at Dio the twenty-third of November, year 1546."

Diogo Rodriguez de Azevedo, who had been entrusted with the letter and the precious pawns, reached Goa within thirteen days and delivered his charge on Tuesday, the 7th December. In less than three weeks from this date the Chamber of Goa made up the required amount, so high stood the Governor's honour and credit in the capital, and the same officer returned to Div with a reply from the Chamber addressed to the 'Most Illustrious and Excellent Captain-General and Governor of India.' The letter, after a long preliminary dissertation, goes on to state that the citizens had, in the course of the interval, 'raised twenty thousand one hundred and forty six Pardaos, and one Tanga, at five Tangas the Pardao, which the city lends, that is citizens and people, as also the Brahmans, merchants, traders and goldsmiths', and adds: 'As for the pawns your Lordship sent us, the city and inhabitants think ourselves injured by your Lordship to rely so little on us and our loyalties; for in a business that so concerned the service of our Lord the King, and his royal state, such honourable and glorious pawns were not necessary . . . . My Lord, Diogo Rodriguez de Azevedo, returns to carry you back your pawns, and he, and Bartholomew Bispo, Procurator of this city, bring you the money which the city and people lend you of their good and free will'. The reply is dated, 'at the Chamber, the twenty seventh of December, 1546.'[1]

Goa subscribes a loan of over 20,000 Pardaos.

It returns the honourable pawns.

A few words are necessary in connection with the later history of these 'honourable pawns', the precious hairs of Dom João de Castro's venerable beard. We are told by his biographer Jacinto Freire de Andrade that, at the time of his writing (1651), they were preserved in the hands of the Bishop, the Inquisitor General, the 'most deserving grandchild' of the hero of Div. The hairs were put in an urn or 'pyramid' of crystal set on a pedestal of silver on which were engraven several distichs commemorative of this famous action. This relic remained with his posterity 'to make hereditary the virtues of Dom João de Castro.'[2]

The hairs were preserved by the Governor's posterity.

1. *The Life of Dom John de Castro*, op. cit., 192-4.

2. Ibid., 192.

Manuel de Lima sent out again to wreak vengeance.

While detained at Div to supervise the rebuilding of the fortress, the Governor ordered Manuel de Lima to proceed a second time with thirty ships along the Gulf of Cambay and burn all the villages on the coast to show to the Sultan that his desire for revenge had not been satisfied by the victory. This captain was, however, instructed not to touch at Gogha because, according to intelligence received, all the troops that had escaped from the battle of Div had taken refuge there. While sailing along the coast, De Lima was overtaken by a violent storm which forced him to take shelter in this very port. The arrival of his ships caused a panic at Gogha as the result of which not only the rabble but also the soldiers fled to a small mountain in the neighbourhood for safety. Dom Manuel now held a council of his staff to decide on the action to be taken and it was voted that they should enter the city 'because the Governor's instructions could not take in all accidents '.[1]

Gogha sacked by the Portuguese Captain.

The Portuguese soldiers almost without resistance entered the town of Gogha and pillaged it. They burnt the houses and all property that could not be taken away. With the help of three Bania prisoners, Dom Manuel proceeded the next day to punish the fugitive inhabitants who had fled with their families to the hill close by and who thought themselves secure. The atrocities that followed had best be described in the words of the Portuguese biographer :

> "Those who thought themselves secure in the mountains saw over their heads the sword, before the enemy. The slaughter differenciated not cause from cause, person from person, natives and strangers, guilty and innocent with their lives paid for their own or another's offence. From persons the affront passed to Religion: he caused many to be hanged up in the temples of their idols, an outrage in the superstition of their religion inexpiable. He cut the throats of all the cattle, sprinkling the mosques (?) with cows' blood, an animal which as the depositary of souls they adore with abominable worship."[2]

Gandhar and other towns sacked and burned.

This unenviable exploit illustrates the ruthless barbarism of the times and the policy of a great European nation in its warfare in the East. After this orgy of murder and sacrilege, Manuel de Lima returned to his ship and in attempting to cross the bay he almost suffered shipwreck without a storm owing to the 'bore' or high tidal waves for which this coast is famous. Sailing down the coast of the mainland

1. *The Life of Dom John de Castro*, op. cit., 194-5.

2. Ibid., 195-6. The expression 'mosque' is evidently intended to mean a temple. The slaughter was mostly of the Hindu population of Gogha.

of Gujarat, he came in sight of the then prosperous port of Gandhar, peopled by Hindu merchants, 'rich by its commerce, weak by its inhabitants.' The town surrendered but was burnt down. The people in vain offered their properties as a ransom for their lives, but to no effect, for the anger, rather inhumanity, of the soldiers coveted blood more than booty. De Lima destroyed many other places in the bay whose names are not mentioned, but whose ruins and ashes kept up for many years the memory of their destruction. The natives who survived these miseries retired to the inland towns where they could lead a life of secure poverty.[1]

The question of a Commander for the Fort.

The Governor's presence being now required at Goa on diverse business, he was anxious to leave the rising fortifications at Div in charge of a capable person, especially as Dom John Mascarenhas, who had been worn out by the siege, had resigned his command with the intention of returning to Europe. Several gentlemen to whom the Governor offered the post declined, probably under the belief that after the late victories there was little honour or glory and less of profit to be gained there. At last Manuel de Lima offered to remain in that port; but at this time news arrived for the Governor to the effect that the Turks had overthrown the ruler of Balsora in Arabia the Happy (Felix) who was an ally of the Portuguese. Upon this De Lima was sent to take charge of the fortress of Hormaz and of the war against the Turks. The problem of the command at Div was thus again revived, and as no one would come forward to take it 'since Dom John Mascarenhas was carrying away with him the glory and the danger', the latter ended the Governor's anxiety by offering to remain for a short time longer at his old post.[2]

J. de Castro invites merchants to settle at Div.

At the same time the Governor left Dom George de Menezes with six ships to sail about the Gulf of Cambay and to proclaim in all the adjacent ports to the Muslims and the Hindu residents there that they might now return to inhabit the island of Div, promising security to their persons and their commerce. On the strength of this assurance, a large number of Hindu merchants and inhabitants came over to settle in the island 'counting that peace secure which began on the confines of war.'[3]

1. *The Life of Dom John de Castro*, op. cit., 196; Couto, Dec. 6, Lib. 4, Cap. 3.
2. Ibid., 197-8; Couto, Dec. 6, Lib. 4, Cap. 4 and 5.
3. Ibid.; 199.

CHAPTER IV

THE "TRIUMPH" OF D. JOAO DE CASTRO AT GOA AND THE LAST STAGES OF THE WAR

The final act of the drama of the Siege of Div was enacted not on the soil of Gujarat but in the distant city of Goa. After a stay of about five months at Div, from Nov. 1546 to April 1547, and when the new fortifications were far enough advanced, the Governor took ship for his capital and arrived within ten days at the bar of Goa on April 19, 1547. Here he was visited at sea by the Bishop, the Commander-in-Chief and the magistrates of the city, with a request that he should halt at Pangim while the citizens completed their preparations for the honour of a Triumph which they desired to bestow on him for his signal victory. The Governor was persuaded to accede to this request for he could not refuse the honour without injustice to those who had been his companions in the great battle or without restricting in some measure the popular rejoicing.[1]

The Governor arrives at the bar of Goa.

The 21st April, 1547 was appointed as the day for the Triumph, a great arch being erected in St. Catherine's Bazaar, the fabric of which was covered with carpets. In order to provide for this imposing entrance, the gate of the city was thrown down and the adjoining walls decorated with hangings of cloth of gold and velvets of diverse colours. On the walls on either side of the great arch were placed gilded lions upholding in their paws the wheels which formed the heraldic symbols of the Castro family. Not far from this site, in the courtyard of the Governor's palace, a miniature fortress was erected to serve as a model of that at Div and within it were placed guns and firearms (charged without bullets), 'a pleasant representation of former horrors.' The structure also concealed musical instruments and players who performed for the delight of the spectators. The adjoining streets were decorated in the same style whilst the citizens had dressed themselves in their gayest clothes. The sea further off was covered with galleys and brigantines with their flags and streamers fluttering gaily.[2]

Triumphal arch and decorations.

1. *The Life of Dom John de Castro* by J. F. D'Andrade, translated into English by Sir Peter Wyche, London, 1664, p. 200; Couto, Dec. 6, Lib. 4, Cap. 6.
2. Ibid., 200-1.

The Governor left Pangim on the appointed day in a specially decorated galley accompanied by his old cavaliers who shared with him equally the danger and the glory. The galleons of the fleet headed the procession of ships up the river of Goa. When the ships came in sight of the improvised fortress they thundered forth a salute which was answered from the shore. Dom João was clad in a rich French suit of crimson satin, and over it he had put on a coat of mail wrought on cloth of gold; he had besides feathers in his hat and the 'guarniture' of his sword was gold.[1] At the quay, the nobility and the magistracy of the city received the Governor and one of the 'consuls' delivered an oration in Latin pointing out how by his valour he had humbled 'the proudest sceptre of the East'. Then came a flourish of musical instruments, while some of the guns discharged diverse comfits as a pleasant feast for the multitude. Further on, under a canopy, a citizen of quality, bowing reverently, took the Governor's hat from his head and placed on his brow a laurel crown for his triumph and in his hand a palm. It is in this costume that the portrait that has come down to us represents the hero.[2]

Dom João receives a laurel crown.

The order of the Triumphal Procession through the streets of Goa has been handed down to us by the Portuguese writers. First came the Guardian of the Franciscans bearing in his hand the crucifix which he had held aloft at a critical period in the battle of Div, representing the saviour with one arm unnailed and hanging. Then followed the 'Royal Banner of our Cinks," after which came the standards of the Gujarat rulers dragged on the ground in the sight of Jujhar Khan and other captive Muslim commanders who walked with their arms pinioned and who 'represented the Tragedy of their fortune, for them compassionate, to us pleasant.' After them were seen six hundred prisoners dragging their chains after them. Last came the field-pieces and various kinds of arms. The ladies who stood at their windows to watch the procession sprinkled the Triumpher with distilled waters of diverse spices. The beautified and open churches 'showed their acceptance and thanks'. 'In this order,' concludes our authority,

The Triumphal Procession at Goa.

> "he went to visit the Cathedral, the Mother-Church of the East, where the Bishop and the clergy received him with the hymn *Te Deum Laudamus*. Being entered into the see, with religious offerings he acknowledged the Author of Victories, and, it being now late, with little ceremony retired to the palace, one day's time being too narrow for the majesty of the Triumph."[3]

1. *The Life of Dom John de Castro*, op. cit., 201-2.
2. Ibid., 201-2.
3. Ibid., 202-3.

The history of the last stages of the war between the Portuguese power and the Gujarat kingdom may now be recorded. The wanton sack of Magdala and Hansot, of Gogha and Gandhar, and the slaughter of their innocent inhabitants, have already been described. Though the actual agent who perpetrated these atrocities was Manuel de Lima, the ultimate responsibility for this Reign of Terror must rest on Dom João de Castro. We shall now refer to another equally atrocious and barbarous act of vengeance perpetrated on the ancient and flourishing seaport of Broach. When he left Div for Goa in April, 1547, the Governor had commissioned D. Jorge de Menezes to commit all possible acts of cruelty in the Gulf, and some months later this captain came in sight of the city of Broach, 'whose stately buildings presented him with the politeness of Europe'. The Portuguese writer describes the town as 'standing on an eminency surrounded by brick walls with diverse bulwarks, furnished with store of ordinance, which commanded the entrance into the haven.' The trade of the place was in very fine silks. 'Madre Maluco' (Imad-ul-Mulk) was lord of the city and had the neighbouring villages tributary to him.[1]

D. Jorge de Menezes at Broach.

The invaders gathered information from some fishermen who were natives of the place, and whose boat had been captured, that Broach was at this time without any garrison for its defence. Imad-ul-Mulk had taken with him all the soldiers to the Sultan's court at Ahmadabad, and the only people left were the artisans and the tradesmen. During the day Dom Jorge, to deceive the inhabitants into a false sense of security, steered another course taking with him the fishermen to serve as his pilots at the mouth of the river. At night, however, the whole fleet tacked about and made for the port where all the men got on shore, there being not a sentinel to guard the place. The soldiers fell upon the unarmed and defenceless population which being awakened in the dead of night from sleep was in the utmost confusion and terror. What followed had best be described in the words of the biographer of De Castro:

He attacks the hapless citizens

"Those who by flying into houses escaped the sword were in them consumed by the fire; the poor people having no remedy against, but choice of their death. The invasion and sack was at the same time: the slaughter as in a fight without resistance, the plunder as in a city forced to deliver. Dom Jorge commanded the city to be burnt, where, in a few hours, the nobility and people, gardens and houses, became compassionate ashes,

Menezes gets the surname of 'Baroche'.

1. *The Life of Dom John de Castro*, op. cit., 206; Couto, Dec. 6, Lib. 4, Cap. 7.

without any distinction of nature or separation of place. This action being so famous amongst our soldiers as to give him who was called Menezes the surname of *Baroche*, as the ruins of Carthage gave Scipio the name of Africanus."[1]

The Governor of Broach arrives too late.

Imad-ul-mulk, the governor of Broach, and father of the more famous Changiz Khan, on hearing of this outrage, came up with five thousand horse, but too late to help. Finding, however, that the fire and the sword had left nothing in its former state, he returned impatiently to the Sultan of Gujarat, and urged him to take revenge for the destruction of this great city as an insult which was aggravated by being the latest of so many others. The Sultan was touched by these news and vowed once more to set upon Div, 'the stone of offence.'[2]

News received of another siege of the Fort by the Sultan.

In August, 1547 letters reached the Governor at Goa from D. Mascarenhas to say that the Sultan of Gujarat had collected together all the forces in his kingdom with the intention of besieging the fortress again.[3] He, thereupon, summoned together the magistrates of the city and desired their help with another loan of ten thousand Pardaos. Though this demand came within a year of the previous one, the citizens offered to place their resources at his disposal and furnished him with the amount. Moreover, the wives of the richer gentry sent to Dom João a large quantity of jewels with a letter of complaint that he had not accepted and spent them when first offered. The ladies of Chaul also again came forward with a more splendid offer, but the Governor 'sparing in the use and expense of so loyal presents' returned them with his thanks. He also sent advice to the people of Bassein and Chaul of the information received from Div and asked that they should be ready for assistance.[4]

De Castro again leaves for the North, Nov., 1547.

De Castro put to sea in November, 1547 with a fine fleet of one hundred and sixty vessels, each under the command of a capable officer, including the governor's son Dom Alvaro, and after some days came to anchor at Bassein. While halting at this place, he sent out spies to find out and

1. *The Life of Dom John de Castro*, op. cit., 207.

2. Ibid., 207-8.

3. There was also another reason for the renewal of the war by the Governor. The cloths produced in Gujarat were sold at Bassein, Goa, Hormaz and Malacca, and the diminution in the customs receipts from these places began to be seriously felt by the Portuguese government. Their trade in the East suffered from the effects of the war with Gujarat. Hence De Castro's attempt to bring Sultan Mahmud III to his knees. (Whiteway, R. S., *Rise of the Portuguese Power in India*, 314-15.)

4. *The Life of Dom John de Castro*, op. cit., 224-5; Couto, Dec. 6, Lib. 5, Cap. 3.

report on the enemy's forces and designs. Being informed that Caracene (? Qara Hasan), the son-in-law of Khwaja Safar Salmani, was in the Castle of Surat with a small garrison, the Governor sent his son Dom Alvaro with sixty sail to go up the mouth of the Tapti, and, after ascertaining the state of the castle, and its garrison and provisions, to attempt to take the fortress by assault. D. Alvaro arrived at Surat bar and forwarded Dom Jorge de Menezes *Baroche* with six fly boats to reconnoitre the fort, but his presence being detected he was shot at from the castle. Upon this the men in the boats turned back either from fear or caution. On their way they received a fusillade from several guns at the village of Magdala where there was a colony of brave Abyssinians. Dom Jorge, thereupon, went ashore and with great courage captured the guns and carried them on board in spite of the resistance offered. He then returned to the fleet and reported his success as well as observations. At a council held by Dom Alvaro the officers of the squadron decided to abandon the idea of taking the Castle of Surat by scaling as the fleet had been discovered and the coast alarmed, the only person holding a contrary opinion being Dom Jorge de Menezes of Broach.[1]

D. Alvaro reconnoitres the defences of Surat Castle.

Meanwhile, the Governor remained at Bassein attending to diverse business. Gasconading in the then approved manner, he gave out that he was proceeding to Ahmadabad to surprise the Sultan in his capital, where, in sight of the Turks who guarded him, he would roast him alive. This threat soon found currency, and to give it additional support Dom John ordered some great spits[2] to be prepared. We are told that the soldiers of those times used to wear little bright axes at their girdles, which served formally to cut the rigging and tackling of their prizes, but the true use to which these were put was to break open chests and bundles. The Governor not liking arms designed for such mean service and seeing by chance a spruce soldier pass by with an axe, told him that only a sword became men of honour. 'Sir', answered the soldier, 'without this axe your honour's spits will be of little use, because we shall not be able to roast the King of Cambay whole!'[3]

The Governor indulges in gasconading.

Dom John de Castro now left Bassein and proceeding northward joined his son at the bar of Surat, and the combined flotilla reached the mouth of the river at Broach. Here an officer was sent up the stream to ascertain the situation, and he returned with the report that the Sultan's troops

He lands at Broach and braves a vast army.

1. *The Life of Dom John de Castro*, op. cit., 230-1; Couto, Dec. 6, Lib. 5, Cap. 6.

2. Spits are bars on which meat that is to be roasted is made to rotate before fire.

3. Ibid., 231.

covered the whole *campagna* by the side of the river as far as the eye could reach. The Governor gave orders for the fleet to sail up the Narbada till it cast anchor in sight of the army. Landing his troops he arranged them in line of battle, but the enemy stood on the defensive. Dom João addressed his officers in council in favour of attacking this vast army, but the disproportion in numbers was so great that he was dissuaded from the attempt. After remaining for three hours on the field, during which time the Sultan's generals made no offensive movement, he re-embarked his soldiers.[1]

Arrival at Div: change of commanders at the Fort.

At last the Governor arrived at Div for the second time and found that the danger to the fortress had disappeared. D. Mascarenhas again reminded him of the leave which he had asked for returning to the Kingdom. The Governor was in a position neither to grant nor to deny this reasonable demand, but was relieved from his difficulty by the arrival of an officer named Luis Falcao who came from Hormaz where he had been in command but had for some questionable practices fallen under a cloud. De Castro was able to offer him the command of the fortress of Div 'that he might by new services silence all former miscarriages remaining in that fortress which had on it the eyes of his Majesty and the whole world.' Luis Falcao accepted the charge.[2]

Further atrocities — Prabhas Patan burnt.

After arranging all matters, the Governor set sail once more for Bassein, and going in sight of the coast of Por and Mangrol (Mangalor) he burnt the city of Prabhas Patan, the inhabitants saving their lives by flight. Besides this, one hundred and fourscore vessels lying at anchor in several ports on this coast were burnt by his order, the poor owners looking on with tears. Many other places on the coast, says our authority, were destroyed, 'this siege of Diu being more famous for vengeance than victory.' Arriving at Bassein, Dom João sent spies to observe the condition of the enemy and these informed him that in the court at Ahmadabad there was not a family without tears, and that the Sultan had by a severe decree forbidden any mention by the people of the siege and battle of Div, 'as if laws could command grief and memory.'[3]

News of the victory arrives at Lisbon.

The fleet which left Goa at the end of 1546 reached Lisbon after a very prosperous voyage and the great news of the victory at Div won by Dom João de Castro was soon spread all over the country. The King and his court, clad in robes of state, attended the chapel on an appointed day to offer thanks to God with pious and royal offerings. A learned sermon was

1. *The Life of Dom John de Castro*, op. cit., 231-33. Couto, Dec. 6, Lib. 5, Cap. 7.
2. Ibid., 233. 3. Ibid., 234-5; Couto, Dec. 6, Lib. 5, Cap. 8.

delivered in which were set forth the praises and virtues of the Governor. The king informed the Pope and the greatest Princes of Europe about the victory, and they all gave him joy 'as for the most famous action of the East.' The Governor in his letters had asked nothing for himself except permission to return home and as a modest request begged of the King two acres of ground adjoining his country-house at Cintra and ending in a little hill which for many generations was called *Monte das Alvicaras* (the Mountain of Good News).[1]

King John III of Portugal, Donna Catherina and the Infante Dom Luis, all sent letters by the outgoing fleet to Dom João de Castro at Goa which show the great regard in which he was held by the royal family.[2] They praised his signal services and the timely reliefs which he sent in the midst of the rainy season to the beleagured garrison, as also his sacrificing his young son Dom Fernando, so full of promise, to the public service. The King declined to give the Governor the permission, which he asked, for returning to the Kingdom, on the ground that his services in the East could be ill spared by the State. He was, therefore, asked to continue in the same charge for another three years with the title of Viceroy, a distinction which he richly deserved but which, as we shall soon see, he did not live to enjoy. The sovereign also granted him a gratuity of ten thousand Crusados to meet the charges which he had undertaken, and letters patent were sent for his son Dom Alvaro appointing him Admiral of the Indian seas.[3] All the letters referred to above were dated October, 1547. The King sent out to India at the end of this year no less than six ships and the one that was the first to reach Goa, on May 23, 1548, brought to the Governor despatches containing the honours and gratuities described above.

Honours and rewards conferred on the Governor.

But João de Castro was not destined to enjoy either the rewards or the dignity. Though only forty-eight years of age, his strength had been worn out by the exertions and hardships of his wars. He had left Bassein in April 1548 ill with fever, and at Goa his sickness soon betrayed mortal symptoms, so that he decided to hand over the charge of his high office. He called for De Albuquerque, the Bishop of Goa, as also for the Commander-in-chief, the Chancellor, the Auditor-General and the Controller of the Revenue, and to them he delivered over the State. Summoning next the magistracy of the city, the Vicar-General of India,

The Viceroy laid up with mortal illness at Goa.

1. *The Life of Dom John de Castro*, op. cit., 240.

2. Queen Catherine, when the account of the victory and triumph reached Portugal, is said to have remarked that Dom João de Castro "had fought like a Christian and triumphed like a heathen." (Whiteway, op. cit., 314; Couto, Dec. 6, Lib. 4, Cap. 6.)

3. Ibid., 254-61; Couto, Dec. 6, Lib. 6, Cap. 7 and 8.

the Guardian of the Franciscans, Father Francis Xavier, as also the Officers of the King's Revenue, he made a short speech which deserves to be reproduced. In striking contrast to many others who held the same high office, and who returned with immense wealth to Portugal, De Castro could say that he died in honourable poverty, a fact which has made his name famous in the annals of the Portuguese in the East. Here is what he said to the council assembled near his death bed:

> "I am not ashamed, Gentlemen, to tell you that the Viceroy of India wants in this sickness those conveniences the meanest soldier finds in the hospitals. I came to serve, not to traffic in the East. I would to yourselves have pawned the bones of my son, and did pawn the hairs of my beard, to assure you I had no other plate or hangings. There is not this day money enough in the house to buy me a hen, for in the fleet I set forth the soldiers fed upon the Governor's salary before the King's pay. I request you during the time of this sickness to order me out of the King's revenue a proportionable maintenance."[1]

His honourable poverty.

After this unusual speech, the viceroy asked presently for a missal and took a solemn oath on the Gospel to the effect that he was not indebted to the royal treasury even by a single Crusado; that he had never received any gratification from Christian, Jew, Moor or Pagan; that all the household stuff employed for carrying out the authority and maintaining the dignity of his high office had been brought with him from Portugal; that he was so poor that he had not the means of buying another quilt than what they saw on his bed; and that he had presented his son Dom Alvaro with a sword to return to the kingdom, the hilt of which was set with jewels of small value. He desired the council to put down all this on record in the public books of the city.[2]

His death in the arms of St. Francis Xavier, 6 June, 1548.

Finding that his end was drawing near, the great Viceroy secluded himself with the famous missionary Father Francis Xavier, 'providing for so doubtful a voyage so secure a pilot, who all the time of his sickness was his nurse, reconciler and Governor.' Having no riches to make a fresh disposal of, Dom João made no other will than that which he had left in Portugal with the Bishop of Angra on the eve of his departure for India. Receiving in his last moments the sacraments of the Church, he gave up his soul to God on the 6th of June 1548 in the forty-eighth year of his age and the third of his government in India. He was thus in the prime of life when death came upon him. In his study were found three pieces of small money, as also a Discipline

1. *The Life of Dom John de Castro*, op. cit., 263-4; Couto, Dec. 6, Lib. 6, Cap. 9.
2. Ibid.

which seemed to have been often used, and the locks of his beard which he had pawned. He had ordered his body to be deposited in the Church of the Franciscans at Goa, to be translated later to his Chapel at Cintra.[1]

His tomb in St. Dominic's convent at Bemsica near Lisbon.

Some reference to the last resting place in Portugal of Dom João de Castro will not be out of place in the history of a province with which his name is so indissolubly connected. Some years after his death his bones were carried to Portugal where they were received with reverent piety, and, after lying for many days in St. Dominic's Convent at Lisbon, were ultimately deposited in the convent of the same name at Bemsica,[2] two miles from the capital. Here they remained for several years until the deceased hero's grandson Francisco de Castro, Bishop and Inquisitor-General, erected a beautiful chapel attached to the convent as a final resting place for them. This Chapel of the Castros, as we may call it, contains the monument of the great viceroy with an epitaph upon it, as also of his son Dom Alvaro, who died in 1575 at the age of fifty, and whose remains were laid by the side of his distinguished father.[3]

Memorial slab at Goa of the victory in Gujarat.

An interesting memorial of the victory of the Governor over the ruler of Gujarat has been for centuries preserved at the city of Old Goa. We have already mentioned that, at the time of the Triumph, a great arch was erected after demolishing a portion of the city-wall, and that it was covered with brocade and velvet. We also learn that above this arch was placed a brazen flag bearing the image of St. Martin,[4] on whose festival

1. *The Life of Dom John de Castro*, op. cit., 264.

2. The Convent of St. Dominic of Bemsica is situated two miles distant from Lisbon and is so named after a neighbouring village. In early centuries it was a country-house of the Kings of Portugal to which they resorted for diversion from business or for hunting. King John I gave up this palace, with the adjacent grounds, gardens and orchards, to the Dominican Order (as an act of thanksgiving to God for his victories in the year 1399) for the founding of a convent. Succeeding rulers of Portugal continued to endow it with revenue to be spent on various religious ceremonials. The convent has been famous as the resort of the strictest observers of the Catholic religion who " under the name of 'Recollets' allow no swerving or indulgence from the first institution." Here, as to a school of virtues, retired the most eminent members of the Order of the Dominicans to rest themselves after their Prelacies in holy leisure devoted to God. (Ibid., 264-68.)

3. Ibid., 265-6.

4. St. Martin, Bishop of Tours (c. 316-400), was born of heathen parents in Pannonia. When ten years old he became a catechumen, and at 15 he reluctantly entered the army. While stationed at Amiens he divided his cloak with a beggar, and on the following night had the vision of Christ making known to his angels this act of charity to Himself. Soon afterwards he received baptism,

day the signal victory over the armies of Gujarat had been won by Dom John de Castro at Div. To commemorate this event a slab with an inscription in gold was fixed in the city wall. After the ceremonies connected with the Triumph were over, the Governor ordered an altar to be raised at this spot, and over it, not long after, the Chapel of St. Martin was built. Many centuries later, when this building had fallen down along with the Royal Hospital and many other monuments of Old Goa, the inscription slab was transferred to the Chapel of St. Catherine, which was adjacent to it, and here it may still be seen. This slab represents St. Martin mounted on horseback and giving part of his garment to a beggar, with the following inscription in Portuguese very rudely carved in uneven letters: [1]

> "Por esta porta entrou Dom João de Castro, Defensor da India, quando triunfou de Cambaya e todo este muro lhe foi derubado, Era de 1547 a (nos).[2]

The English translation of the above is as under:

"By this gate Dom João de Castro, Defender of India,[3] entered when he conquered Cambay,[4] and this whole wall was destroyed for him. Era of 1547 years."

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left the army and joined Hilary of Poitiers. His zeal against the Arians roused persecution against him and for some time he led an ascetic life on a desert island near Genoa. In 371-2 A.D. the people of Tours chose him for their Bishop. He did much to extirpate idolatry from his diocese and from France and to extend the monastic system. He died at Candes in the year 400 A.D., and is commemorated by the Roman Church on Nov. 11. He is the patron saint of France and of the cities of Mainz and Wurzburg.

1. Correa, *Lendas*, IV, 637; Diogo de Couto, Dec. VI, Liv. IV, Cap. VI; *Oriente Conquistado*, Part I, Conq. I., Div. I., Sd. 37. (See also Fonseca, J. N., *Sketch of the City of Goa*, 227-8).

2. For full details of this most interesting inscription slab, a photograph of which was kindly secured for the author by Rev. H. Heras through the Very Rev. Fr. da Dosta, Canon of the See of Goa, see article entitled "A Portuguese Inscription of the Goa Governor Dom John de Castro" by H. Heras in *Journal of Indian History*, April, 1933. As stated in the text, the inscription is very rudely carved, the words are not separated from each other nor are the last words in each line divided by syllables.

3. The title of "Defender of India" is not less strange than that of "Governor" or "Viceroy of India" assumed by Dom J. de Castro and others. But by 'India' the Portuguese writers meant, not the sub-continent as we do now, but only their possessions in the East under the Governor of Goa which constituted the *Estado da India*.

4. Cambay stands here, as usual, for the "Kingdom of Cambay," the name by which the Arab and Portuguese navigators and merchants, as well as literary writers, designated the Sultanate of Gujarat, from the fact that the main seaport of this kingdom for several centuries was Cambay.

VIŚĀLGAṚH INSCRIPTIONS

Viśālgaṛh fort has played an important part in the history of the south Konkan. It was a very strong fort and once the capital of the government in the twelfth century. It is situated on the Gajāpur hill in the Sahyādri range, about forty four miles north-west of Kolhāpūr (16° 55′-73° 47′). It was formerly called Khelnā, and Muḥammad Qāsim Firishtah, in his history, refers to it by that name. Rājah Sirke, in 1453 A. D. (850 A. H.) treacherously led Malik-u't-Tujjār, the commander of the Gulbargah forces, towards Sangameshwar.[1]

History of the Fort:

They had to pass through intricate paths, tortuous passes and dreadful labyrinths which have been described by Firishtah in a very picturesque style. All of them were trapped and killed there in the midst of the forests. This dangerous trick was avenged by Khwājah Muḥammad Gāwān in 1469, when he could, by hook or crook, take possession of the fort of Khelnā (Viśālgaṛh). Then the fort came under Bījāpūr in 1489 A. D. when the Bahmani dynasty ceased to exist. Our inscriptions belong to this period. It remained under Bījāpūr up to 1659 when it was captured by Shīvāji, who gave it to Parashurām Trimbak as a grant and the present *jāgīrdār* Mehrbān Ābājīrāo Krishnarāo is one of his descendants. In 1730, when Kolhāpūr was finally separated from Satārā, the grant of Viśālgaṛh was continued to Janārdan Pant Pratinidhi by a fresh patent or *sanad* passed by

1. I have followed the Persian text of "*Ta'rikh-i-Firishtah*", Nawal Kishore Ed. Vol. I, p. 334, that Sirke deceived Malik-u't-tujjār by saying :—

میان من و رای سنکیسر (=سنگمیشر) همسری است

"Between me and Rāi of Sangameshwar there has been a rivalry." Mr. Briggs, in his translation of this book writes that Sirke's rival was Shankar Rai, Rājah of Khelnā. [Briggs, II, 437]. I think he made a mistake in reading شنکر for سنکیسر .

Grant Duff reads it differently :—

"Mullik-ool-Tijār insisted on the Rājā's (Sirkay's) renouncing his own faith and embracing the tenets of the Korān. The enraged, but subtle, Rājā...... humbly represented that there existed between him and the Raja of Singur, a fort in the territory of Kondan, a family competition and rivalry."

[*N. B.*—Mullik-ool-Tijār is a wrong transcription of the word ملك التجار Malik-u't-Tujjār.]

The source is mentioned as Mahratta manuscripts, and the word Singur is identified with Singh-gadh. Grant Duff's *A History of the Mahrattas*, Ed. 1912, Vol. I, p. 46.

Sambhāji (1712-60). Till 1844 Viśālgaṛh continued to be the head-quarters of the Kolhāpūr Pratinidhi when the fort was dismantled and the head-quarters were moved to Malkāpūr.

There is a mosque in the fort which is dedicated to Malik Raihān Pīr. The Persian inscription on the wall of this mosque runs :—

" The Maratha king named Bhoj held the fort, I Malik Raihān came and six times besieged it without success. In the seventh siege I took it. Be brave and thou shalt prosper."[1]

The Gazetteer is silent about the date and the Persian epigraphy of this inscription.

History of the epigraphy:

There are two other Persian inscriptions in the fort. The facsimile of the inscription No. 1 was in the hands of Messrs. Graham,[2] E. Rehatsek,[3] and H. Blochmann,[4] but none of them could decipher and explain the whole of it. Mr. E. Rehatsek's reading was hopeless and Mr. H. Blochmann read the word بخوب as بخواب and gave a fantastical explanation to that and did not try to explain the knotty point of the date given by the chronogram and the words within the " Lozenges."[5]

He made another mistake too. He hazarded an opinion :—"In fact from its Indian style and manner of composition I believe it cannot be older than Aurangzib's reign."[6] But from these impressions it is now quite clear that his judgment was wrong.

Mr. E. Rehatsek tried to defend himself against the attack of Mr. H. Blochmann but failed.[7] He tried to give some explanation about the date of the chronogram but failed therein also.[8] So the doubt raised by Major Graham regarding the date of the inscription still remains as it was. Now with the help of these impressions I am able to give an explanation regarding the date.

Inscription No. 1.

These impressions were given to me by Dr. Balkrishna, M. A., Ph. D., Principal, Rajaram College, Kolhapur, about five years ago, when he had brought them from Viśālgaṛh fort. It is a Persian Rubā'ī, in Naskh style and its metre is هزج مسدس محذوف (= مفاعیلن مفاعیلن فعولن) It measures 19"x 12".

1. *The Gazetteer of Bombay Presidency* (Kolhāpūr), p. 323.
2. *Report on the Principality of Kolhapur* by Graham, p. 339.
3. *Ind. Ant.* II, 372.
4. Ibid., III, pp. 219 and 344.
5. Ibid., III, p. 344.
6. Ibid., III, p. 219, f. n.
7. Ibid., III, p. 265.
8. Ibid., II, p. 372.

My reading of the epigraphy in the inscription No. 1 is as follows:

Plate No. 1

(1–2) بود، کار جهان جمله بهمت ـ تمامی شد بخوب این برج دولت

(3–4) اگر خواهی که تاریخش بدانی ـ کنون تاریخ گویش برج دولت

Translation.

1. All the work of the world is performed by courage.
2. This "*Burj-i-Daulat*" was completed in beauty.
3. If thou wishest that thou mayest know its date,
4. Now its date is: "Call it *Burj-i-Daulat* (the bastion of fortune.)

All the above mentioned scholars have thought that the last hemistich gives the clue that the words "*Burj-i-Daulat*" give the date which numerically comes to 645 only. But in my opinion the word گویش does not mean "say to him" or "say the date". Because in the first hemistich nobody else is asking the date but the poet is himself addressing the reader. In a chronogram like the following the word گوی may mean what the other scholars have taken it to do in this chronogram.

"کسی پرسد اگر تاریخ آن را ـ زهی عالی بنای خیر گوئی"

(A. A. Bilgrami, "*Landmarks of the Deccan*," p. 27.)

But in the present case the words گویش برج دولت should be translated "call it *Burj-i-Daulat*."

The Chronogram:

The numerical value of the chronogram گویش برج دولت by the *Abjad* system[1] comes to 981 A. H. (1573-74 A. D.). So we find that this year does not coincide with the date given in the inscription No. 2 which is 996 A. H. The cause of this difference may be that the poet might have composed the chronogram in 981 and the slabs were inscribed and put up in 996.

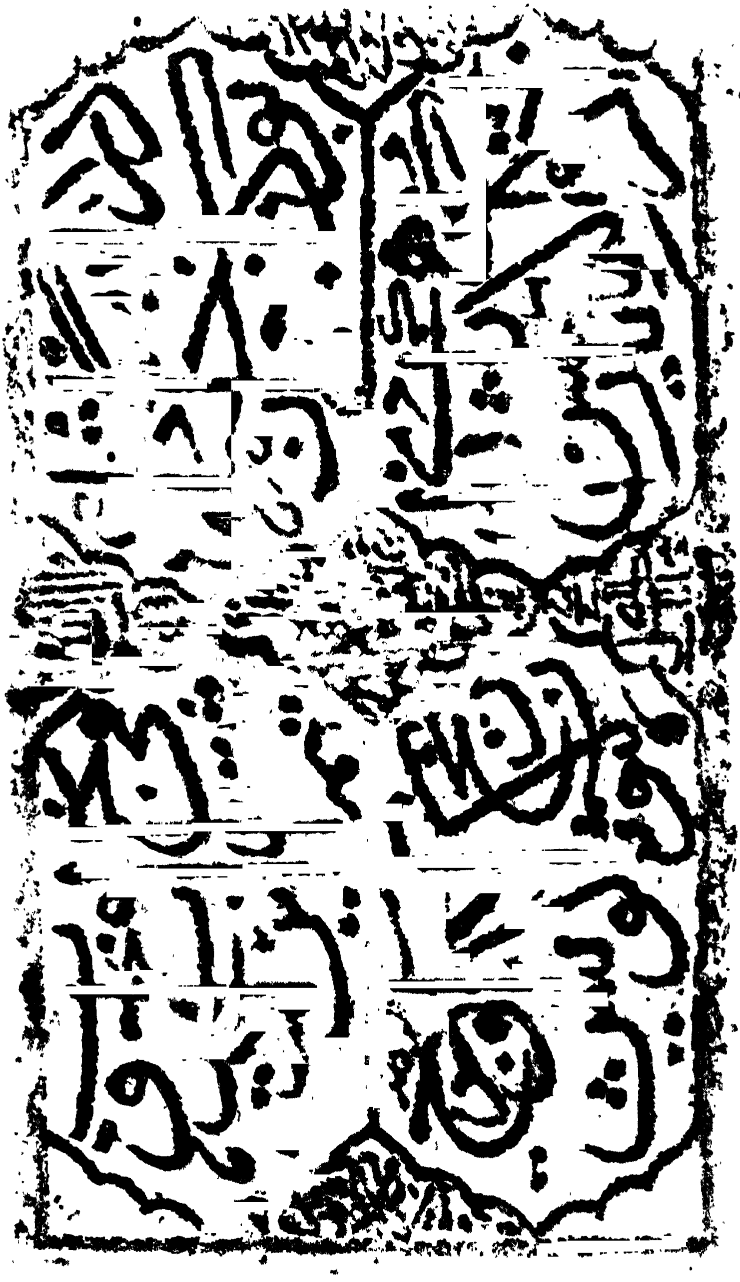
In the middle of the epigraphy, within the "Lozenges" I have deciphered the following words which were perhaps not taken into consideration by Mr. Graham when he took the facsimile. They are written in *Ṭughrā* style :–

Right hand corner — هجرة نبوی (٩٩٤؟)

In the middle, upper lozenge. الله الباقی

1. 20+6+10+300+2+200+3+4+6+30+400 = 981.

1 3



2 4

VIŚALGAṚH INSCRIPTION No. (1).

VISALGARH INSCRIPTION No. (2).

SCALE [illegible]

In the middle, intervening lozenge. ابراهیم عادلشاه خلد الله ملکه ؟

" " ". " lower lozenge. کل شی هالك [1]

Left hand corner, ... illegible.

The upper and the lower lozenges read together mean: "God is eternal. Every thing is perishable."

Inscription No. 2.

This inscription has not been noticed by any scholar as yet although it is very important because it gives the date in figures which are quite clear. Then the name " Ibrāhīm Shāh " is repeated in the body of the verse also. This shows that Ibrāhīm 'Ādilshāh was reigning in the year 996 A. H. (1588-89 A. D.) and he cannot be any other Ibrāhīm but " Ibrāhīm 'Ādilshāh II. " Firishtah says that Ibrāhīm 'Ādilshāh ascended the throne in the year 988 A. H.[2] and Asad Khān Lārī also in the "*Haft Kursi* " *i.e.*,

نسخهٔ هفت کرسی از اسد خان لاری قلعدار بلگانون

gives year 988 A. H.[3]

There is no doubt that by looking to the style and the language of these two inscriptions we can say that they were inscribed and put up at one and the same time. The stone measures 25″ × 9½″. I have deciphered the text as follows :—

Plate No. 2

[4] (1–2) بود کار جهان جمله بهمت - عمارت شد بابراهیم شاه دولت

(3–4) اگر خواهی که تاریخش بدانی - کنون تاریخ گویش برج دولت

1. This is the part of a Qur'-anic text. Chap. XXVIII. (Al-Qaṣaṣ)

کل شی هالك الاّ وجهه 9-88.

" Every thing is perishable but His face etc. . . "

2. Firishtah, *Tārikh* (Persian text). II, 47.

3. My Ms. of هفت کرسی was copied from the manuscript of India Office Library and is a chronological record of the reigns of the 'Ādilshāhī kings of Bījāpūr. p. 47

4. In this hemistich I think the word بابراهیم was inserted through the misunderstanding of the calligraphist. Just as nowadays we have " the printer's devil " so in those days they suffered from "the calligraphist's devil." The poet must have composed " عمارت شد بامر شاه دولت "but the calligraphist who had written in the intervening " lozenge " ابراهیم عادلشاه thought that the words بامر شاه were a mistake for, بابراهیم شاه

Translation.

(1) All the work of the world is performed by courage.
(2) It was built by (the order of) Ibrāhīmshāh of good fortune.
(3) If thou wishest that thou mayest know its date.
(4) Now its date is: "Call it *Burj-i-Daulat.*" (the bastion of fortune).

Right hand corner. . . . . . دلاور (خان)

In the middle. Upper lozenge. . . . . . . یا غفور

" " " Intervening lozenge. . . . ابراهیم عادلشاه

" " " Lower lozenge. . . . . محمود باشند (؟)
Left hand middle lozenge . . . . Illegible.

Left hand lower corner. . . . (year 996. H.) سنه ۹۹ع

The upper and the lower Lozenges read together mean:
"O Pardoner, May he be praised."

I read the year given in the left hand lower corner as 996 A. H.

The figure ع in the unit's place of the date was read by Mr. E. Rehatsek as 4 [1]; by Mr. Ghulām Yazdāni in one place as 5 [2], and in the other as 4 [3], and by Mr. A. A. Bilgrāmi as 6 [4]. Mr. Bashīr u'd-dīn does not refer to it.[5]

I read the figure ع as six, because wherever this figure has occurred in the plates of the published Indian Moslem-Epigraphy it was found, on examination, that if it be taken to represent six the year coincides with the events, kings and names referred to in the epigraphy.

B. D. VERMA

1. Cousens, *Architecture of Bijapur*, page 35.
2. *Epigraphia Indo Moslemica*, Volume 1915–16, page 32.
3. Ibid., Vol. 7, 1919–20, plate 14, p. 25, Mr. G. Yazdāni reads the year as 947 A. H. (1540-41 A. D.) when no history says that the Nizāmshāhi Kings had their hold in that part of the Deccan. (Briggs, II, pp. 228-229). So that year also, in my opinion, should be read as 967 A. H. (1559-60 A. D.) when Ḥusain Nizām Shāh حسین نظامشاه was reigning, who was the bravest of the Nizāmshāhi Kings. (Briggs, II, pp. 237–249)
4. *Landmarks of the Deccan*, by A. A. Bilgrami, page 139, f. n. 1.
5. "*Wāqi'āt-i-Mamlikat-i-Bijāpur*" by Bashīruddin, III, 449-454.

THE HISTORY AND HISTORIOGRAPHY OF INDIA

It is our object in the following article to discuss the validity of certain assumptions on which historians have attempted to construct narratives of India's past. With inadequate equipment, with no acquaintance with the theory of history, lacking the habits that fit them for their task they yet sit down most confidently to describe events exactly as they have happened. Their only anxiety is to fit out a real past; they have a haunting terror of shadows. That is why they are incapable of rising above the level of the mere chronicler.

The consequence has been that our histories are generally one-sided and present a misleading view of the past. It would appear that our historians have joined in a conspiracy to encourage a very narrow and unedifying conception of the purpose of history. By deliberately limiting the field to "what really happened" they have fallen victims to tradition in dealing with the past. They give us no insight into its true nature, into the content of its life as such. For, the story of India's past is wholly unlike that of any other country known to the world's history. It is essentially the history of the creative spirit struggling to express itself in a synthetic quest all through the ages. To comprehend it, it is not enough to watch the destinies of royal dynasties, the rise and fall of great empires.[1] We have to watch and note how this creative spirit permeates the institutional efforts of man in society and state; how it breaks into cadence of song and verse; how it perpetuates its own embodiment in stone and colour; and how finally, it expresses itself in the inner existence of man in terms of self-realisation. The perusal of mere events, of wars and crimes,[2] leaves behind the impression that our history is a mausoleum of dead issues. We cannot, indeed, help being filled with sorrow at the panorama of suffering and travail that the picture of our past unfolds. The most glorious empires that the genius of man could have

1. "If human history were merely a matter of wars and rumours of wars, kings and merchants, there would have been no artists and scholars, philosophers and scientists. The modern world would know nothing of music, nothing of pure science, and poets would have given immortality to warriors, but never have thought of skylarks, Greek Urns or some lost paradise. To omit from history these striving after that which is true and beautiful and good is forgetfulness; to reduce them to mere aspects of the economic struggle is brutality." —Shailer Matthews: *The Spiritual Interpretation of History*, p. 29.

2. It is this perusal perhaps, that makes Gibbon say "History is little more than the register of the crimes, follies, and misfortunes of mankind."

erected, are now mouldering in ruins, choked up aqueducts, crumbling palaces and deserted cities. We see ourselves surrounded on all sides by heaps of ruins and our soul sinks into the deepest despondency with a griping, torturing dread of the inevitability of the biological law. We seem already to hear the rumbling of the approaching storm that would sweep our present also, in its turn, into the limbo of forgotten things.[1]

We thus get the impression that our past is a debris of ashes and bones. We fail to realise that it abounds with ideals and beliefs, with the achievements of the soul. We forget how little India has cared even to keep a record of her political events, for they were not the things that really mattered. She has revelled in things of the spirit and has always been a home of philosophers. The records of her kings are indeed neglected; but words spoken by an Yagnavalkya or a Buddha or a Sankara are still remembered, zealously preserved in scriptures that would never die. The history of India is the record of the spirit, of the mind which expresses its thought in an endless quest: "Ever old, Ever new."

It is necessary, hence, to place India's history on its proper footing, and rescue it from genealogists, coroners, collectors of anecdotes, chroniclers of courts, of princes, and of nobles, who have trespassed on a province far above their own—" those babblers of vain things," to borrow the language of Buckle,[2] " who lie in wait in every corner, and infest this the public highway of our national literature." We can never grasp the dignity and value of the story of our past unless we could dive below the surface of these superficial presentations of facts to comprehend the spirit that filled and determined the content of life. The emphasis of the political sense, of the kingly *nexus*, has deprived most of our historians of the ture perspective. We reel through a bewildering maze of lifeless irrelevant, unedifying details presented with no selection or proportion. Freeman's famous epigram, " History is past politics," reinforced by great worthies like Ranke, Seeley and Sybel, still holds the field, and Carlyle's warning passes unheeded that, " far away from senate houses, battle-fields and kings' antechambers, the mighty tide of thought and action was still rolling on its wondrous course."[3]

Our historians do not realise that what we wish to know is the man as such, for is not man more than a warrior or a subject or a prince? They do not recognise that history's mission is to give us the content of his life, and that they should, therefore, appraise the world of facts in terms of value, reaching the subterranean spirit of the soul,

1. Cf. Spengler's Theory: *Decline of the West.*
2. *Civilization in England,* Vol. II, p. 347 (World's Classics).
3. See Robinson's *The New History,* p. 7.

the inward of which the outward humanity is but the expression.[1] What we wish to know is not the dead man, the fossil in itself, but the living thinking being he once was, his hopes and aspirations.

Our history, lest we court death, is not to be treated as a dead past, a past that has ceased to be. It has to be transfused into the living actuality it once was, by sweeping away the illusion of time, even as Carlyle insists. History, in its essence, is a resurrection; the flush of life in dead limbs. From the view of our realistic historians, the object of history is the past, an aggregate of things finished happening. But an event that has finished happening is just nothing, is non-existent.[2] To think of the past as simply the past is as hopeless as the metaphysician's search after things-in-themselves. The past as a thing-in-itself has no existence. It must be an ingredient of our present life, by not only being capable of being remembered but also experienced. Historical facts are not merely remembered facts but also experienced facts. We could live all history in our own person,[3] for is not history the continuous attempt at the adventure of living?

We must, therefore, turn our back on realistic historians who are too much influenced by the temporal aspect of time to realise the unity of the Eternal, who consequently miss the perpetual presentness of the past. Every true history is contemporary history, because, as Benedetto Croce has rightly pointed out, it is the present producing of the spirit.[4] It is unfortunate that we should try to differentiate between different periods of time and thus miss all that is of human interest. There is a fundamental identity underlying human nature in all times and places. Otherwise, we could never account for the quick response of the modern man to the play and interplay of elemental human instincts, as they appear in some form or other in ancient literature. The fountain of our interest is that we pass again through all the periods of existence, ourselves alive in them. As much as the poet, we become what we sing. We live along the whole line of Asokan pillars and Taj Mahals, the Ibadatkhanas and Panipats. The pageant is conjured up in its reality and we become, indeed, "spectators and sufferers in the event." How can we account for the perennial appeal of the Mahabharata, the Gita, the Upanishads, the Ramayana and the 'Shakuntala'? How can we explain the attraction of the Ajanta Frescoes, even after the lapse of centuries? How is it, that even at this distance of time we are powerfully moved when we read the tales of Rajasthan? Do we not merge ourselves in the sad

1. Cf: Taine's *History of English Literature*.

2. See R. G. Collingwood's Article, *Journal of Philosophical Studies*.

3. See Emerson's *Essay on History*. See Max Müller: *Selected Essays*, Vol. II, p. 11.

4. *Theory and History of Historiography*, p. 11, ff.

thoughts of the crowned philosopher, who, turning away in sorrow and disgust from the harrowing spectacle of warring creeds and contending beliefs, sought refuge in the conviction that slowly dawned in his soul, that no single tune held the key to the infinite? Shall we be wrong, therefore, in building upon the postulate of identity of human nature and in insisting upon the human interest of the past?

History, thus, is not simply the past. Neither is it the event. The dominance of the 'narrative' spirit has vitiated the whole outlook of our historians. We generally get a bewildering catalogue of names and dates. All kinds of facts are given publicity in print, because we happen to stumble upon new documents or inscriptions. There is no question of selection or proportion; the anxiety is to present events as they really happened. Trifling details of dynasties and military history, lengthy personal anecdotes occupy much of the space, for, the historian thinks he has no right to express any verdict upon the facts or to grasp the theory underlying them. The construction of narrative chronologically arranged, is *not* history. It is something more. Facts are mere dross, as both Ruskin and Macaulay hold, and it is from the thoughts, the abstract truth that the events and happenings embody, that history derives its value. History is the thought that expresses itself, the mind that records, and mind is prior to the fact. All history, that is to say, is in a sense in the mind of man.[1] It is the Law of man's being, the Idea in its potentiality, the Universal in its Spirit, even as Hegel would have it.[2]

The past, therefore, simply regarded as the past in the crude realistic sense, is wholly unthinkable. The past that we try to reach is not a world of things-in-themselves, a world that has ceased to be, and so an isolated fact. Such a fact can never be related to the present; the chain of linkage is severed into its links. And yet, it is this linkage that is really significant; engrossed in the mere 'past,' we fail to grasp the continuous force which binds age to age, connecting the past and the future. Life is a lengthening chain and the social structure is continuous. We discover, how closely we are related to our forefathers, who sang the paeans of the Rig-Veda though so far removed from them in distance of time. Emerson has said that man is a quotation from the past; it would be truer to say that he is the epitome of all the ages. He inhales as his spiritual atmosphere the experience and knowledge of the past. "Man has been," writes Graham Wallas,[3]

1. Our statement might be misunderstood, and we hasten to point out that this is not as a pre-composed symphony. Lotze has truly maintained, (See Ward: *The Realm of Ends: Pluralism and Theism*, p. 310) that it is the irresistible demand of the spirit that history must be more than the translation into time of an eternally complete content.

2. See his *Philosophy of History*, Introduction.

3. *Our Social Heritage*, p. 19.

"increasingly dependent on social heritage." He is what he is, because of this; because, his father was what he was. Our fathers "are largely the stuff of which our present selves and our present world are made of."[1] It is only the savage that recognises not the rock from which he is hewn, the pit from which he is dug.[2] A realistic conception of India's history will prevent us from discerning its connective tissue; that its dense web 'is woven without a void,' to borrow the phraseology of Lord Acton.[3] History interpreted as narrative of political events chronologically arranged, will miss the underlying unity and continuity of India's past. The political history of this country would appear neither smooth nor continuous. It seems jerky, made up of separate and apparently unconnected events, and thus discontinuous.[4] But the history of India is something more. The spiritual unity that the history of our past presents to us is, as Das Gupta truly observes, "essentially one of spiritual aspiration and obedience to the Law of the spirit, which were regarded as superior to everything else."[5] The unity and continuity of Indian History lies not in its physical course, but in the plane of idea. The history of India is essentially the history of idea as distinguished from the history of fact. The continuity that smoothes its pages comes not from the facts in themselves, "for they are in the raw discrete, accidental, jumbled and discontinuous"; it comes from the vital relationship of our present to our past in the realm of spiritual striving; physical separateness does not affect the truth of this relationship. "Viewed from the standpoint of intervening space, the distance between the earth and the moon may loom large and tend to obscure the fact of their relationship."[6] And yet the earth and the moon are vitally intertwined in the plane of the spirit. The continuity of our history is thus neither physical nor biological.

To the eye of the philosopher, the history of India is, therefore, one vast continuous whole. We shall have to seek to embrace it in its spiritual unity. We shall only then assign each fact that is presented to us to its fitting rank in the scale of social progress. We cannot isolate and treat in isolation each fact from the series of temporal or

1. J. A. Smith in *The Unity of Western Civilisation*, p. 72.

2. Sir Flinders Petrie: See his article on "Discovering the Unknown Past" in Harmsworth's *Universal History*, Vol. I. ("The power of regarding the past and of understanding the causes which has produced the present form of affairs is one of the greatest tests of civilisation.")

3. Lectures on Modern History; first Lecture: "Inaugural Lecture on the Study of History."

4. See C. W. Cole's Article: "Relativity of History," *Political Science Quarterly*, Vol. XLVIII, No. 2.

5. *History of Indian Philosophy.*

6. Rabindranath Tagore: "A Vision of India's History." Vide *The Visva-Bharati Quarterly*, April 1923,

spatial succession. Our knowledge of the past is a present awareness; present experience taken in as a unity, as a "synthetic unity," to borrow the expression of Croce,[1] which may reveal sequence in space and time; each unit of the sequence, however, not as a fact-in-itself, unrelated to others, but in organic relation manifesting the rhythm of the flow of real life. The past of India is the living relic of the present. The India of the past is a projection of itself into the India of the present. That is why we have said that the true nature of India's history is its contemporaneousness. Whatever of the past goes into our present experience, is history in the largest sense of the word.

It is just here, that the historian diverges from the annalist. The historian is concerned with values and not with facts-in-themselves; he tries to interpret movements and tendencies. Facts can be recorded by ordinary observers. Those of us who have studied original manuscripts and inscriptions know very well that most of the writers of this category of historical evidence are not celebrated for their literary accomplishments and other mental endowments. They try to describe as faithfully as they can what they believe to be authentic events. They could even piece together, by a series of dates more or less precise, the events that they describe. It would not be difficult indeed, to date the accession of a monarch, or the change of a dynasty, and in such instances, it might be possible even to be accurate. The historian, however, is neither an antiquarian, nor a genealogist. His mission is loftier; and we shall comprehend it by realising that real history is the history of truths and tendencies, perceived by the mind, and not of events which are merely physical. How can we date movements of the mind in the world of human affairs! It is the assignment of value, not the assignment of date, that is, therefore, of supreme importance.[2] The question of chronology leads us into the realistic meshes of things-in-themselves, for, any experience of ours is at once temporal and eternal. Its ingredient 'parts' cannot be comprehended apart from their unity. Philosophers like Dr. Radhakrishnan and historians like V. A. Smith may hold that "in the absence of accurate chronology, it is a misnomer to call anything a history," and that a "body of history strictly so called must be built upon a skeleton of chronology, that is to say, on a series of dates more or less precise." Evidently, there is a serious confusion here between the office of the annalist and the function of the historian. History is not putting bits of information, chronologically arranged together, like beads on a string.

Everything depends on our understanding history, not as a past,

1. B. Croce: *Theory and History of Historiography*, p. 12.

2. H. G. Wells complains that historians, "go in fear of rather small errors than of disconnectedness; they dread the ridicule of a wrong date more than the disputable attribution of a wrong value."

but as a present interest. The so-called historical facts are not in themselves absolute. They are valid as related to our view of them. Those, who essay to construct narratives of events, exactly as they have happened, seek for objectivity where it is an illusion. For the facts themselves do not exist apart from our idea of them. They have no value if they cannot be referred to the meaning that they embody. This reference, which yields for us their significance, is essentially subjective; it is our estimate based upon selection and interpretation. And in this task of selection and interpretation, the historian has to make use of hypothesis as much as other investigators. He has to start with a theory, for historical facts have to be "related to a frame of reference." "Without reference to some theory," says Cole,[1] "the fact is an isolated entity of dubious validity and little meaning." The historian has to see, even as Darwin did, that all observation must be for or against some view if it should be of any use. Bacon's advice that we should renounce, for a while, our conceptions and try to acquaint ourselves with the things themselves would land us again into the world of things-in-themselves. The attitude of detachment is psychologically impossible and untenable. Open-minded we shall be; but open-mindedness, "does not mean mental vacuity."[2] We shall indeed be impartial; but the impartiality of the historian is not that of the mirror which merely reflects.[3] Historical truth does not exclude earnestness of conviction, for it is to serve as our common tribunal.

But to serve as a common tribunal, we might be reminded, history must be above contention. Its facts must be authentic, well-established. Everything depends however on what exactly we mean by the authenticity of history. If history is a present interest, mere annals in themselves are not history. They must be inspired by conviction. Historical facts are real, not in the empirical sense as our realists would have it, as events that had really happened. Truth in history is that which is accepted by the intellect and approved by conscience; for historical truth is concerned with human values. Those facts of history are true that satisfy our sense of right and justice; that can be related to our present experience in a significant way. Others must stand condemned at its bar.

And when we talk of experience we might be told that history "is a hybrid form of experience, incapable of any considerable degree of 'being or trueness';"[4] for, the "being or trueness" of history is held to be its verified and verifiable certainty. And where this is not pos-

1. Article: "The Relativity of History," *Political Science Quarterly*.
2. See Allen Johnson: *The Historian and Historical Evidence*, Chapter on the "Use of Hypothesis."
3. See Temperley's J. B. Bury: *Selected Essays*, pp. 70–71.
4. Bosanquet: *Principle of Individuality and Value*, pp. 78–79.

sible, a sceptical attitude is assumed and effort is dissipated in trying to sift what is supposed to be authentic, unquestionable fact from myth and legend. It is not realised in the first place, that even if we accept the veracity of all those records that have come down to the present, they after all constitute a very insignificant part of life. And where there are no records it is very readily assumed that there is no history either; as if historical truths depend upon their memory being preserved in the form of chronologically connected narratives.[1] "The essence of history," as Ratzel has well put it,[2] "consists in the very fact of happening, not in the recollecting and recording what has happened." And further the kingly *nexus* of our historians vitiates their outlook by the makebelieve, that history is a record of political events. We are, for instance, solemnly told by one of our historians,[3] that there is no history of Hindustan in the fifteenth century, which is, according to him, a formless epoch. And yet, he admits that elements out of which modern society arose, were taking their origin in that century. E. B. Havell has done well in pointing out that it will give us a very imperfect impression of Indian life if it were assumed that, "the somewhat sordid record of Muhammadan dynasties contained all that is most important to remember in the history of the period and absorbed the greater part of the intellectual activities of the people."[4] Our historians, however, are very scholarly and pedantic. They must needs turn courtiers and valets, and lose themselves in unedifying efforts to establish the authenticity of genealogical tables and birth-dates. What they want are facts, facts which can never be challenged. We must witness their wranglings, to be convinced of the futility of their attempts. One of them would tell us that Kautilya may be dated, anywhere, between 400 B.C., and 400 A. D.! Another would triumphantly bring forth a series of genealogical tables that he has most fortunately stumbled upon, to establish the fact, that Shivaji is verily a scion of the 'SURYA-VAMSA,' and that he could be traced back to the Sun himself! While yet another historian, turned coroner, is not satisfied by the simple statement that a certain Rajah died on the battle-field. It is a well-known fact, and nobody has as yet questioned its veracity. Our coroner-historian will not be satisfied, however, before he has marshalled evidence running into some pages, from about a dozen sources to prove the death of the Rajah! Unfortunately for these chroniclers, genealogists, and coroners, they are not the only "historians" in the field. There are many others, like themselves, who take up the refrain in heated controversies. The audacity of their mutual faultfindings is

1. See Shailer Matthews: *The Spiritual Interpretation of History*, pp. 38–39.
2. *History of Mankind*, p. 5.
3. Rushbrook Williams: *An Empire Builder of the Sixteenth Century.*
4. *History of Aryan Rule in India*, p. 407.

astounding. While one would suggest that the other has consulted writings, the language in which they are written he is absolutely ignorant of, another would claim that he alone possesses certain manuscripts which throw a wholly new light on history altogether. Every one claims that what he is establishing, are historical facts!

But what is a historical fact? "The answer," says Cole,[1] "is that it is, at its best, what the historian thinks of what someone else thinks he saw or said or did or heard. At its worst, it is a paltry third or fourth-hand judgment." Some thinkers have even called historians liars. The "being or trueness" of history, as we have already pointed out is made to depend upon its verifiability. The unerring certainty of conclusions that we arrive at in the physical sciences, is not possible, it is held, in history, because of the inherent difficulties of experimentation. History is, therefore, regarded as a hybrid form of experience.

But the question of the veracity of historical evidence is, after all, irrelevant from our conception of history. The word, "History," originally meant "enquiry" and only secondarily came to be applied to the embodiment of the results of inquiry in the particular form of narrative. The Greek word for "history," is "Historia" meaning search after truth. The "being or trueness" of historical facts, their objective reality as such, will land us again into the realistic meshes of the world of things-in-themselves. For, we ask along with Benedetto Croce: "How could that which is present producing of our spirit ever be uncertain?" It is only by effecting a divorce between life and thought in history that we are tempted to doubt the certainty and utility of history. History emerges from the very bosom of life constituting the unity of our experience.

Each historical fact, isolated in its objectivity, however simple and clear to our realists, is simply non-existent for us.[2] It has no meaning, and can have no meaning. Facts as happenings, are atomistic, if they are not related in the vital synthesis of our experience. And because we hold that history is essentially this unity of experience, we turn away from the mere welter of isolated facts to a construction from within in terms of personal values of an ordered universe of reason and truth. Facts, by themselves, are, that is to say, particular. History,

1. "The Relativity of History," Article in *Political Science Quarterly*, Vol. XLVIII, No. 2.

2. C. W. Cole says, "With all the will to objectivity in the world, with all the honesty that can be conceived, with all the desire to tell things exactly as they have happened, the historian cannot produce work which has at the same time, significance and a close relationship to something that objectively existed in the past." (Article on "The Relativity of History.")

on the other hand, is universal, for our experience, in its nature, is universal. On the assumption that history teaches only the particular, Schopenhaur had denied to history the character of a science. But how could that which springs from the bosom of life, which is verily its very content, be particular! How could that which is a present interest merged in our existence as an ingredient of experience be treated in its objective isolation!

The History of India, as we conceive it, is not a mere welter of discordant facts, a record of kings and wars. It is essentially the embodiment of striving after that which is true and beautiful and good. It is the concretisation, through the actions of men, of the Eternal Quest to know and realise Reality. We cannot omit from our history the strivings of our philosophers, poets and prophets; a material rendering would make it coarse and brutal. Our history is essentially spiritual, pregnant with tendencies and movements that have deeply affected our humanity. Tendencies and movements, in their very nature, can never be treated as objective realities, because they are not physical facts, sensed by our external faculties. They can only be comprehended by the mind; and as such, could be reduced to a system of concepts capable of not merely philosophical, but even scientific treatment in the highest sense.

Our conventional historians might retort that in all that we have been so far seeking to establish, we are only taking refuge in a barren subjectivity, which is futile this side of metaphysics. Our view or experience of history might be merely an imaginary construction, which must appeal itself to the "facts of history." These facts they might say, form the permanent background of reference, while our view of them might perpetually fluctuate. If history is concerned with values, how then, could that which is mere change yield any principle of interpretation? On the one hand, the world-process itself, objectively considered, is a series of changes occurring in mere succession; a mere flow of facts. It is only an intellectualised construction that presents them to us either as united or continuous. To use Bergsonian language, it is a cinematographic view of history. If each fact were to be treated as such, apart from the flow, then its disconnectedness becomes manifest. How could that which is in itself isolated be referred to a theory which alone can appraise it in terms of value. On the other hand, apart from the objective world, our mental processes also vary, and verdicts based thereon, would therefore constantly fluctuate. Our own view might change from time to time; the view

1. "The Sciences," he says, "in that they are systems of concepts speak entirely of universals. History speaks of particulars which betoken a contradiction."

of our generation likewise might differ from other generations. "Every generation," Trietschke has said, "has the right to portray the past as it appears to his own eyes." It would be impossible to recover values and truths from history. There seems to be great force in Macaulay's[1] regret that history is "sometimes fiction and sometimes theory."

That historical verdicts fluctuate, we readily admit. It is the incessant demand of the human spirit that they shall fluctuate. Otherwise, we would merely duplicate narratives, already extant. "History," said Goethe, "must from time to time be rewritten, not because new facts have been discovered, but because, new aspects come into view, because the participant in the progress of an age is led to standpoints from which the past can be regarded and judged in a novel manner."[2] Our moral and social standards change with the passage of time.[3] Every generation, as Mark Pattison points out, requires the facts to be recast in its own mould, and demands that history be rewritten from its own point of view. This is an unconscious factor affecting all historians, both ancient and modern. Polybius himself has commented on it. It has been said that the younger generation feels pleasure in tearing down the idols of the old.[4] So theories come and go. Prejudiced, therefore, with our present prepossessions, how, it may be asked, can we have any idea of the past as it was in itself ?

This is a very specious argument. History, as we have said, is not mere spatial or temporal succession, implying change in space and time. The comprehension of succession is its awareness as a unity in experience. There can never be mere change and succession as such. They are only relative; they are change and succession in reference to a comprehensive principle. Change is never fortuitous; there is no chance,[5] properly so-called in history. History is not even a record of pulsations, as Huntingdon[6] has called it. Ideas of history based upon these premise are atomistic; they try to present the multiple facts of change and movement without co-ordination. Bare pluralism lacks reason; we do admit the force in the arguments of our opponents, if they mean that the historian has to start with a multiple hypothesis, for life being complex, no single interpretation would do. But if they assert that no interpretation is possible and that changing facts can

1. Read his essay on History.
2. See Teggart : *Theory of History*, p. 7, ff.
3. See Prof. R. W. Seton-Watson's Article XX " A Plea for the Study of Contemporary History," in *History*, Vol. XIV, No. 53.
4. See Pritchard : *Essays of Today*, pp. 14–15.
Ben Lindsey : *The Revolt of Modern Youth.*
C. E. M. Joad : *The Present and Future of Religion.*
5. See R. L. Schuyler's Article on "Law and Accident in History," in *Political Science Quarterly*, Vol. XLV, No. 2.
6. *Pulse of Progress*, p. 318.

only permit of objective presentation we have only to remark that this is a serious misunderstanding. To recognise the difficulty of a thing is not to admit its impossibility. Our main difficulty, indeed, is not the discovery and presentation of facts but the discovery of a comprehensive principle that would relate these facts in terms of historic law. And yet this is the true function of the historian. Our conventional historians are concerned only with the accumulation of personal details, trivial recitals of the deeds of kings and of wars, and of the intrigues of courts. Our object, on the other hand, to quote the noble words of Voltaire, is "to write a history, not of wars, but of society; and to ascertain how men lived in the interior of their families, and what were the arts which they commonly cultivated"; in short, our object is "the history of the human mind, and not a mere detail of petty facts.... " We wish to study the general march of civilization, to interpret the origin of laws and customs. In a higher sense "Civilisation is the fact *par excellence*"[1] which demands our study—"a general definitive fact, in which all the others terminate, into which they all resolve themselves." We cannot exclude it from history without mutilating it. We may well ask with Mallet, who in 1755 published his history of Denmark, "Why should history be only a recital of battles, sieges, intrigues, and negotiations? And why should it contain merely a heap of petty facts and dates, rather than a great picture of the opinions, customs, and even inclinations of a people?" By concentrating on the great march of human affairs, as Montesquieu has done in his "Spirit of Laws," it may be possible to rise superior to the accidents of history, as that great thinker characterises the events which ordinary historians relate. It would then be possible to discern the relation of events to each other, the connection that unites them. This is so because the method is essentially philosophical. It was through this method, that Turgot, who may share with Voltaire, Montesquieu and Hegel, the credit of having created the philosophy of history, arrived at a principle of order amidst the apparent confusion of variety of events. He could thus seize upon the history of man as a whole. In our view of historiography, laws and manners, thoughts and aspirations constitute the very soul of history. Indeed, they are history *par excellence*. Wars, anecdotes of kings, acts of Government are material and visible facts, and it is very easy to compile narratives of them. But their demand on our attention is not, in our opinion, more imperative than of the philosophical facts that can only be comprehended by the mind. Montesquieu relates the reign of six emperors in two lines. We shall likewise interest ourselves with more comprehensive things.

Objective reality, moreover, is an illusion; it must exist for some-

1. Guizot: *History of Civilisation*, Vol. I, p. 5.

body to be noticed. When we accept this, we at once introduce the subjective element. Every historian, however self-effacing he would try to be, cannot help putting something of himself in his own work. Our conventional historians would indeed protest and say that history must be very impartial. But this is a metaphysical absurdity. As Prof. A. F. Pollard maintains, "imagination" must stand in the forefront of the qualities, that make the ideal historian. "Eliminate personality," says Prof. Seton-Watson, "and you eliminate human nature, and what is history then but a wretched husk ?"[1] Moreover, the historian is first and last a moral being. If he tries to press his personality out of his handiwork, it becomes mechanical and alien. Freedom demands that the historian shall recognise himself in his creation; the interest of history shall be, in the first instance, his interest. In any other sense, he is an annalist or chronicler; his initiative of thought and action in servitude to imperative objective facts.

History, moreover, is not a mere record of fluctuations. Tennyson never doubted that, "through the ages one increasing purpose runs"; and this purpose is the measure of the progress attained by mankind. The multiple phenomena of history, of movement and change, do illustrate the working of Law. Law is not mere interpretation of change, but is the manifestation of development. Thus Muller Lyer accepts "Progress" as a fact of social development. As Bodin expressed long ago, "there has been through the ages of oscillations a gradual ascent."[2] No doubt there is always change, for "history largely depends upon the will of men, which is always changing, every day new laws, new customs, new institutions." But in all these shifting scenes, we do discover a tendency which compels the recognition of spiritual forces, if not a Spirit, in social development."[3]

Our conventional historians, unfortunately, divert our attention to the accumulation of dead facts, in their despair of finding any principle of unity. They insist that all we need is facts, and more facts. Mere massing of detached facts, they never realise, is not history. History can never be an aggregation of events or happenings. It is only when we become conscious of the supreme significance of history as the realisation of the Spirit, of the manifestation of God in the human world, that we can rescue this branch of study from its present degradation. History reveals the presence of God. Through history, we obtain, as Flint says, "a veritable increase of our knowledge of

1. Article on "A Plea for Contemporary History" in *History*, Vol. XIV, No. 53.

2. Quoted by Bury: *The Idea of Progress*, p. 39.

3. Shailer Matthews: *Spiritual Interpretation of History*, p. 6.

God's character and ways." We discern the design of Providence, the fulfilment of God. The story of mankind, and more especially of India, is the record of the eternal quest to comprehend life in its spiritual unity.

We, therefore, urge with all the emphasis we are capable of, that we shall have to set aside received notions and begin with a novel approach in the task of reconstructing India's past. It is time we realised the fallacy of our old conceptions of historiography. So long as our histories continue to be written from the standpoint of the mere "past," of the mere "event," our narratives would lack the tone of reality because divorced from life. Our plea is that history must, hereafter, be written from the standpoint of "life." For history is the human epic, and nothing less. It is a titanic struggle for the realisation of freedom.

The history of India, "with all the changing scenes, which its annals present, is this process of development and the realisation of the spirit; this is the true *Theodicaea*, the justification of God in History......"[1] What has happened, and is happening every day, is not only not "without God," but essentially "His Work."

The historian of India shall therefore not lose himself in the happening as such, but shall realise the Spirit which is the life-impulse. History, in other words, shall seek to justify the ways of God to men.

PRATAPAGIRI R.

1. The language is Hegel's *Philosophy of History*.

FINANCE AT THE INDIAN ROUND TABLE

So much attention has been concentrated on the 'political' side of the Round Table that comparatively little regard has been paid as to what difference *economically* the Reforms are going to make to the people of India. The people of India want self-government undoubtedly because they want to breathe free air and tread proudly on a land which is free because it is self-governed. But they also want more food, more education, more hospitals, more drainage schemes, better sanitation—in a word, they look forward to enjoying those material amenities of civilised life which the peoples of the west now enjoy as a matter of course. All that necessarily involves finance, and I am here concerned with examining how far the financial arrangements now embodied in the White Paper secure this desirable end.

It may be of interest to glance at the following few indices of the economic background which denote the compelling need for large public expenditure on the social services:

Births per 1000	35·47
Deaths „ „	25·95
Hospitals and Dispensaries	·0175[1]
Colleges and Schools	·849[2]
Railway Mileage per 1000 sq. miles	23
Road Mileage (metalled) per 1000 sq. miles ...	65[3]
Literacy per 1000 persons	76
Population employed in factories per 1000 persons ...	6·3
National Income per head	Rs 75 or £5 12 6
„ „ „ „ (Simon Commission)	Rs. 100 or £7 10 0
Average expectation of life at birth	23

I may also point out that agricultural production per acre in India compares very unfavourably with that abroad; while, during the last 10 years, the area under "culturable waste other than fallow" and

1. There are 1682 State 'special hospitals' for Railway, Police and other services, which, if taken into account, would bring the average to ·02.

2. There are 34,114 unrecognised institutions of a very low standard which, if added, would make the average ·978.

3. If the unmetalled roads are also taken into account, the figure is 232.

"fallow land" have remained constant at 155 and 50 million acres respectively.

These figures indicate in some measure the main problem of India. The people are poor and therefore cannot afford a large payment of tax revenue. At the same time, they need a large public expenditure on the social services to reduce their poverty and enable them to pay more in taxes. They certainly cannot afford an expensive governmental machinery. One may well say that the Indian economic situation required a prudent Finance Member to bear in mind

(1) the very low taxable capacity
(2) the need for a cheap governmental machinery
(3) the need for a comparatively large expenditure on the social services.

These necessary determinants of Indian public finance have been ignored in the past and are now sought to be ignored foı the future as well. It is this neglect which has associated Indian public finance with Indian poverty ; and since the objective of a new India is the removal of this poverty, the people legitimately look forward under a new constitution to obtaining a financial system that will permit a large expenditure on national development for the improvement of both its material and human content.

A sound system of public finance like this is associated in the Indian mind with a new government mainly because of historical reasons. Public expenditure and revenues, in India as elsewhere, have grown with amazing rapidity during the course of the last 70 years. From a total of Rs. 436 millions in 1861, public expenditure debited to revenue reached Rs. 2252 millions in 1929–30, the last year for which I have consolidated figures for the provincial and central governments. Taxation was severely raised during the war and the period immediately following ; and later on, the three years following 1929 have witnessed another period of a great rise in taxation. Probably, India is the only example of a belligerent country whose taxation to-day stands far higher than it did immediately after the War. And yet, the government we are maintaining by this far greater expenditure is one that very largely is as restricted in the scope of its functions and the exercise of its beneficent activities as its predecessor in 1861. A great deal of the increase in revenue, brought about chiefly by increase in taxation—our revenue from customs and income tax developed mainly as a result of a rise in rates—has been swallowed up in inflating the expense of a governmental framework that is not any the more efficient to-day than it was 70 years ago. The following table speaks for itself,

Expenditure per 1000 persons in Rupees

	Essential Services	Social Services	Tax Burden
1876	1810	159	1974
1886	2108	166	2073
1896	2142	201	2205
1906	2462	277	2562
1912	2514	302	2911
1921[1]	4511	588	5136
1929	4210	876	5402

It is only during the last 10 years—after the introduction of the Reforms and a certain measure of Indianisation of the Services—that a tendency in the other direction is noticeable; and even with that, the essential services—defence and maintenance of law and order—claim nearly 83 per cent. of the total expenditure (on services excluding the expenditure on civil works). Even the Percy Committee on Federal Finance (1932) find themselves forced to make a mild reference to this distressing fact.[2] Indeed, the dominance of this economically unproductive expenditure in the financial system of a country that essentially requires the dominance of productive expenditure[3] can be reasonably described as one of the chief causes of Indian poverty. For the effect to be removed, the cause needs removal; and the only way to do that is to *reduce* the expenditure on the essential services.

The long over-taxed British public may feel that the incidence of taxation in India is low and that I am not taking into sufficient account the possibilities of an increase. In that connection, I should like first to dwell on the general consideration that the lower the national per capita income, the greater is the burden of a given amount, more especially when you consider, to quote Sir Walter Layton, " that an unusually small proportion of the revenue raised is used in services which are of direct benefit in raising the status of the masses of the

1. Figures for expenditure on army and civil departments of Government of India are for 1922-23, as those for 1921-22 are inflated by the War.

2. "The opinion is widely held in India that the cost of government already exceeds what can properly be borne by a predominantly agricultural country, and it would be deplorable if the first result of the reforms were a large addition to the overhead charges of Government."—Report, p. 16.

3. Discussing Indian Expenditure, Sir Walter Layton points out: "Wise expenditure on social services and particularly on health and education should be remunerative in the sense of increasing the wealth-producing power and, therefore, the taxable capacity of a country. Security is, of course, essential, if production is to develop; but it cannot be claimed for expenditure on defence either that it is a mere redistribution of income or that it promotes production efficiency."—Simon Commission's Report, Vol. II, p. 216.

people."[1] Then again, a primary classic land of villages, agricultural India is too poor to afford even from the fiscal point of view any increase in indirect taxation; as a matter of fact, statistics of salt consumption have proved that even in the case of such a necessity consumption reacts rapidly to a rise in duty, while increases in customs duties on imports have also produced a noticeable reaction. Indirect taxation is already high in India, while direct taxation, on account partly of the small number of rich people[2] and partly of the high rates of duty, does not possess much elasticity. The other chief items of revenue—land revenue and excise—are notoriously inelastic, while probabilities of additional provincial taxation are exceedingly remote even if there did exist possible sources.

The situation can truly be described only as a vicious circle. Taxation is heavy because it is badly spent; and a continuance of existing bad spending inevitably means that you cannot get additional revenues by taxation to redress it. Whereas, if once the vicious circle is broken, and taxation not being raised, more is spent on the social services, production will increase; tax yield will increase; and more will become available for expenditure on the social services. It is the *initial* push which is needed, and that can only come from a reduction in the expenditure on the essential services.

How far does the new Constitution make this possible? An answer to this question takes one straight away into a discussion of the vexed problems of Indian federal finance. Confining myself to the financial relations between the British Indian Government and the provincial governments, I may say that to some extent the question is identical with that of *essential* v. *social* services. The central government is almost solely concerned with the essential function of defence; its other functions are largely ancillary. The provincial governments, on the other hand, have charge of the nation-building departments; education, medical relief, public health, industries, agriculture—these are all provincial subjects. This, of course, does not tell the whole story. The central government performs 'social' services when it maintains scientific departments and grants subsidies; the provincial governments perform 'essential' services—to a much larger extent than the central government performs social services—when they maintain law and order and spend money on police, jails, courts and general administration. During the year 1929-30, *e.g.*, the central government spent Rs. 711 millions on essential services as against Rs. 27 millions on social services; the provincial governments, on the

1. Simon Commission's Report, Vol. II, p. 238.

2. In 1929, the number of people paying income-tax with annual incomes exceeding £150 were hardly 300,000.

other hand, spent Rs. 225 millions on social and economic services as against Rs. 404 millions on essential services. And it is symptomatic of the dominance of 'essentials' in Indian public finance that the almost wholly 'unproductive' central government should have a revenue equal to that of all the provincial governments put together.

In a sense, one can say, the running thread of Indian public finance—ever since Lord Mayo's decentralisation scheme of 1870—has been the struggle of the provincial government to increase its resources at the expense of the central government; and it was the minor success, which it obtained in 1921, that enabled the social services to gain a little at the expense of the essential, in the period 1921–1931. But the Meston Settlement of 1921 left the provincial governments, with their expanding needs, only diminishing or at best constant resources; while to the central government, with its diminishing needs, it gave expanding resources.

The vicious principle which weighted the scales in favour of the 'unproductive' central government still seems to hold sway, signifying the continuing dominance of the essential services. It is interesting to watch the progress of this 'demon' down the Round Table.

The Second Round Table Conference appointed a sub-committee,[1] under the Chairmanship of Lord Peel, to consider the whole question of federal finance. This committee admitted that "provincial expenditure, more particularly on 'nation-building' services, may expand into fresh channels, whereas the range of Federal expenditure is more confined"[2] and "there may be a natural and a proper tendency for Provincial and States' Expenditure to increase, despite economies, and for Federal expenditure perhaps to decrease." And they decided *unanimously* that with the exception of the super-tax on companies, the net proceeds of the income tax should be redistributed to the provinces. Fearing a federal deficit, they recommended that contributions should be required from the provincial governments (the exact amount and basis to be determined by a later fact-finding committee); but they also laid down:

"We further propose that, not merely should it be the declared object of the Federal Government, as its position improves, to reduce and ultimately extinguish the contributions, but *the constitution should specifically provide for their extinction by the Federal Government by annual stages over a definite period, say, ten or fifteen years.*"[3]

1. Among others, Majors Elliot and Stanley, and Mr. Pethick Laurence were members of this Committee.

2. Indian Round Table Conference (2nd session), Sub-committees' Reports, p. 24.

3. Italics mine.

The fact finding Committee with Lord Eustace Percy as chairman —it is curious to note that while this committee contained two representatives from Indian States there were none from British India— worked out the details of contributions,[1] the net result being that out of a total of Rs. 135 millions from the income tax, 85 millions should be retained by the Federal Government and 50 distributed to the provinces. As regards the 'automatic extinction' of these contributions, however, the Percy Committee were of opinion that, "on the data now available, it is impossible to specify an annual rate of reduction of contributions or a definite period within which it could be anticipated with reasonable certainty that the natural growth of federal revenues, at the rates of taxation we have assumed, would enable the Federal Government to extinguish these contributions altogether."[2] The demon of the 'essentials' had regained one foothold.

Province	+ Surplus or —Deficit on the basis of present provincial revenues	Share of income tax (figures in lakhs of Rs.)	Full contribution payable proportionately to the amount under column 3	Contribution proposed	Final Surplus
Madras	— 20	1,83	1,15	1,41	22
Bombay (excluding Sind)	— 65	3,22	2,03	2,48	9
Bengal	—200	4,05	2,55	2,05	nil
United Provinces...	+ 25	1,23	78	95	53
Punjab	+ 30	91	57	70	51
Bihar and Orissa...	— 70	1,07	68	35	2
Central Provinces.	— 17	59	37	37	5
Assam	— 65	29	18	nil	—36

Compiled from Tables IVA and IVB, Percy Committee's Report, pp. 22-23.

Then came Sir Samuel Hoare's statement to the Third Indian Round Table Conference on 6th December 1932 emphasising the importance of Federal solvency. "As matters stand, therefore, the centre cannot surrender any substantial portion of its revenue; and if the Peel plan were applied in the present circumstances, this would merely mean that the proceeds of the income tax would be transferred and the whole amount taken back in the form of contributions."[3] Sir Samuel Hoare suggested a constitutional division of income tax receipts plus, of course, contributions. The third Round Table Conference was acquiescent; and the White Paper on Indian Reforms accordingly provides:[4]

1. Indian Round Table Conference (2nd session). Sub-Committees' Reports, p. 32.
2. Percy Committee's Report, p. 17.
3. Article 57 (page 29), The White Paper. Cmd. 4268, 1933.
4. Indian Round Table Conference (3rd Session) Report, pp. 58-59.

"(1) Corporation Tax, and receipts from the income tax on officers in Federal Service, and the tax attributable to Chief Commissioner's Provinces or other Federal Areas, will accrue to the Federal Revenues.

(2) The remaining net proceeds will be divided between the Federation and the Governor's Provinces, x per cent. being assigned to the former and the remainder to the latter; x not to be less than 25 per cent and not to be more than 50 per cent.

(3) Federation to have right of surcharges on taxes on income."

In addition, there are to be contributions from the provinces, to be taken as a block amount from their share of the income tax; these contributions to be extinguished in ten years, unless the Governor General decides not to do so.

When considering this arrangement, one has to bear in mind the following essential determinants of any scheme for Indian federal finance:—

(1) The revenues of the Federal Government are elastic; but provincial revenues are notoriously inelastic.[1]

(2) The possibility of increasing revenues—both Federal and provincial—by new taxation are very remote; this is particularly true of the provincial governments.

(3) The provincial governments are in far greater need of money as their spheres include the main nation-building departments; while the central government has as its main function only defence.

(4) If increased expenditure on social services is desirable, then increase of provincial revenues becomes absolutely necessary; the central government spends on social services only $\frac{1}{20}$th of what it spends on 'essential' services, while the corresponding proportion for the provincial governments is nearly thirteen times larger.

(5) The only way of increasing the provincial revenues is, as the Government of India themselves pointed out in their despatch on constitutional Reforms,[2] by surrender to provincial governments of

1. To quote Sir Walter Layton: "From now onwards any increase of revenue from existing resources—except receipts from large irrigation schemes in the Punjab and Sind—is likely to be small. The stagnation of other revenues will affect all provinces alike."—Simon Commission's Report, Vol. II, p. 235. Also cf. the Percy Committee: "Provincial sources of revenue are, for the most part, comparatively inelastic and cannot be expected to respond as quickly as central revenues to a recovery in economic conditions."—Report, p. 5.

2. "We should also be glad to see as much latitude as possible allowed in framing the schedule of provincial taxes; but the provinces will have to rely, in the main, upon the gradual surrender to them of the central revenues from salt and personal income tax."—Cmd. 3700, 1930, p. 63. This fact is also admitted by Sir Malcolm Hailey in his memorandum on federal finance. H. C. 112 (111).

some of the central revenues. And yet, under this new arrangement, only a part of the income tax is going to be transferred; but, what is given will be taken back by the central government in the shape of contributions. The provincial governments are just to carry on, with their budgets just balanced; where they cannot, there will be subventions from the centre, such that provinces which otherwise might have had a surplus will pay for those who have a deficit; and, in the words of the Secretary of State for India, "these subventions would do no more than start the deficit Provinces *on a bare subsistence level.* But if there is not enough money to go round, they must tighten their belts and wait for better times;"[1] and the erstwhile surplus-budget provinces[2] will presumably also tighten their belts and wait for better times. In the meanwhile, the Federal Government will balance its budget, " fulfil its obligations and remain solvent ".

The final stage in the triumphant progress of the 'demon' of essential services is reached with the memorandum submitted by Sir Malcolm Hailey to the Parliamentary Joint Select Committee on the India White Paper. With a wealth of detail it was proved that the financial position of the centre was in danger and a significant appendix hinted at the dangers of depriving the centre of any of its existing financial resources. Sir Samuel Hoare, using the memorandum as the basis for a further statement, was more explicit. "I think it is most important to emphasize the fact that, so far as we can see, for quite a number of years to come, there is no orange to divide up in India between the centre and the provinces. The fact that does emerge, any how, in my mind as definitely as any other is that for some years to come the central Government, whether it be the present Government or whether it be a Federal Government, will need substantially its present resources if the credit of India is to be maintained and if its financial obligations are to be met." The Secretary of State therefore ventured to impress upon his friends among the Indian delegates. "With the best will in the world, if we are to have a stable Central Government, if Indian credit is to be maintained, and if Indian commitments are to be met, there is no sum at the moment to be divided up amongst the Provinces other than, say, a part of the jute tax or some such payment of that kind for dealing with the very exceptional position of Bengal." The last hope of the provinces obtaining even a claim to a share in the proceeds of the income tax had now disap-

1. The 'bare subsistence level' finds another honourable expression in Sir Malcolm Hailey's memorandum.

2. If Rs. 50 millions of income tax receipts were transferred to the provincial governments without countervailing contributions, there would be 5 surplus-budget povinces, with a total estimated surplus of Rs. 25 millions.—Percy Committee's Report, p. 22.

peared. The Indian Social Services were to be crucified on the cross of Indian stability and credit. No wonder Indian literacy, Indian wealth and Indian happiness receded in dismay before the advancing majesty of the 'stable' central Government and its 'fulfilment of obligations'.

It may be retorted—well, what is wrong with it? It is all very unfortunate, but surely the Federal Government must maintain its solvency! We hope it will not be added as well that the social services can wait for better times; for our main contention has been—that better times will not arrive till the social services expand, and you cannot answer me by saying that social services cannot expand till better times arrive. The vicious circle must be broken and that can only be done by a substantial increase in the expenditure on these services.

That brings us to our second main contention in this paper, viz., that it is possible for the federal government to surrender some of its revenues—we would suggest for surrender the income tax and the excise on salt— and without calling for provincial contributions, still "fulfil its obligations and maintain its solvency." By transferring the items we suggest, the central government will lose a net revenue of Rs. 180 millions; and its effect on the budgetary position would be, on the basis of the forecast of the Federal Budget compiled by the Percy Committee, a deficit of Rs. 145 millions. For reasons explained in an appendix to this paper, we cannot accept the Percy Committee's estimates of federal income; we would reduce them by Rs. 44 millions. Their estimates of expenditure, leaving defence alone for the moment, will have to be increased by Rs. 20 millions, in view of the subsidies necessary for the two new provinces of Orissa and Sind. So that on the basis of the Percy estimates—appropriately revised—our proposals will involve a federal deficit of Rs. 220 millions. Will that not mean federal insolvency and inability to fulfil obligations?

A word about this 'fulfilment of obligations'. The normally-minded Englishman primarily associates this phrase, when used in connection with the budget, with the payment of interest; and aware as he is of the large sterling obligation of the Government of India, he is keen on Federal fulfilment of obligations. May we give a short picture of the obligations of the Government!

On 31st March 1932, the Government of India had a total interest-bearing obligation (including sterling loans) of Rs. 12,121 millions

against which there were interest-yielding assets[1] of Rs. 9632 millions, leaving a total of Rs. 216 millions as obligations not covered by specific assets or cash. The interest on these, at 5 per cent., would amount only to Rs. 10·8 millions; and against this 10·8 millions, the net contribution which the Railways make to general finance is at least Rs. 50 millions. This deficit, therefore, cannot really affect the interest-paying obligations of the Government of India. The nervous English invester need spend no sleepless nights worrying over the intricacies of Indian federal finance.[2]

What these suggestions will affect is the power of Government to maintain unimpaired its present scale of expenditure, and that means chiefly the military budget. The Percy Committee assigns the military budget Rs. 470 millions out of a total federal expenditure of Rs. 801 millions. If the expenditure on 'Frontier Watch and Ward' is also included, the percentage of the total expenditure spent on 'defence' rises to nearly 61. It has long been held by Indian economists, and with justice, that with a much smaller expenditure—say Rs. 270 millions—the function of the defence of India can be as efficiently discharged as it is to-day. The reasons for the present inflated character of the military budget are mainly political and are traced below under the heads of the strength, composition and post-war growth of the Indian Army.

The strength of the Army.—The total strength of the Army in India was 316,670 in 1931; of these, the fighting services proper—excluding Administrative and Military Engineering services—numbered 246,788, with an Officer personnel of 4,200. The present numerical

1. The details are:

	(millions Rs.)
Capital advanced to Railways	7523·3
Capital advanced to other Commercial Departments	254·8
Capital advanced to Provinces	1649·6
Capital advanced to Indian States and other interest bearing loans	204·3
Total	9632·0
Cash bullion and securities held on Treasury Account	333·7

—Cmd. 4161, 1932, p. 19.

2. For people who still doubt, let us quote the satisfying and respectable authority of the Financial Correspondent of the London Times: "The total interest-bearing debt of India expressed in sterling amounted to £909,400,000 of which £726,700,000, or nearly 80 per cent., is represented by interest-yielding assets. Interest from these assets, however, together with additonal net profit derived from commercial departments, has in the past sufficed to meet the interest on the whole public debt."—10th May.

strength of the Army is far greater than is necessary strictly for the purposes of Indian defence. This excess strength is due to several causes.

(*a*) An unreasonable fear of Russian invasion has resulted in a forward frontier policy which requires a military strength considerably greater than that necessary for the defence of the Indian plains. On this matter, opinion has been divided even in members of Government, and the 'civilian' has looked askance at the 'militarist' straining the Indian budget. It may be useful once more to make clear how illusionary this bogey is, and for that purpose, I would like to quote Colonel Hanna who had active experience on the Frontier. He pointed out that Russia possesses no base in Central Asia for the organisation and supply of a large army; that the acquisition of Afghanistan would not furnish her with one, and, therefore, she must remain, for all purposes of an invasion of India, hundreds of miles away; that the Transcaspian Railway is hampered by want of water and is open to Persian attack and that if it were extended further, it would be in constant danger of 'sandstorm or snowstorm, earthquake or flood', and open to the attacks of the Afghan tribes, and therefore this Railway is a precarious means of communication; that in any case Russia would be in the necessity of organising a large animal transport train; that Central Asia and Afghanistan cannot supply the beasts of burden sufficient to move a force adequate to such an enterprise; that their numbers, even if they can be obtained, would make it impossible to feed them; that if all these difficulties were overcome, there is no point within striking distance of British territory where a Russian army could halt to concentrate and recruit, and that by whatever route it might elect to advance, by one line or many, it would always enter India in a succession of very small bodies."[1]

As a more recent observation (December 1932), we would like to quote Mr. F. G. Pratt, C. S. I., I. C. S. (Retd.), until recently Commissioner of Northern Division, Bombay Presidency.[2]

"Cut out the 'Russian' menace, obliterate the visions of a Soviet Napoleon leading vast hordes of Russian peasants over hundreds of miles of wild and trackless and mountainous

1. Quoted from Vakil: *Financial Developments in Modern India.*
2. *The Military Burden on India*, p. 7.

> country for the conquest of India and what other dangers call for insurgence? Afghanistan? In order to maintain friendly relations, must Indian diplomacy be equipped on a world-war scale? The North West, Frontier? It is more secure and peaceful to-day than it has been for a generation. A network of motor roads has been spread over Waziristan, and its key positions are occupied by strong permanent garrisons of regular troops."

In final support of our contention, we would draw attention to the pacts of non-aggression recently signed by Russia with all her neighbours, including Afghanistan. There is no reason why the Indian Government should not make a similar pact with Russia. It is also evident that with her present internal programme and an aggressive neighbour in Manchuko, Russia is too occupied even to dream of an armed invasion of India.

(*b*) The Indian Army has been often employed outside India for Imperial purposes—there were 19 such occasions between 1838 and 1920—and even the Simon Commission frankly admitted the Imperial importance of the Indian Army.

This Imperial significance is bound to increase with every step taken in disarmament and reduction of land and air forces by the Great Powers in Europe.

(*c*) The Indian Army is a reserve force for quelling internal disturbances of a revolutionary character against the *British* Government in India.

(*d*) Partly by reason of the peculiar composition of the Army and partly on account of some unknown reason of military policy, the Indian Army is always maintained on a war-time basis.

It is clear, therefore, that the size of the Army could be considerably reduced without affecting in any way its essential efficiency for Indian defence.

Composition of the Army.—Ever since the so-called Mutiny of 1858, a fixed ratio has been observed between the British and Indian personnel in the Army; this ratio, needless to say, is determined on *political* grounds of danger to the British Government in India and not on *military* grounds of efficiency for Indian defence. And to-day, the Indian Army consists of two sections—one a British Army, a regular part of the British Army, all British, privates and officers, and stationed for a limited period in India with a total strength of nearly 60,000; the other is an Indian Army, with Indian privates and a majority of British officers, with a total strength of about 180,000.

The importance of this particular racial composition—maintained for political reasons—in swelling the expenditure on defence is clear when it is remembered that a British soldier costs nearly four times as much as an Indian soldier; while a British officer costs more than five times an Indian officer.

As a matter of fact, in 1932–33, 58,841 British officers and soldiers drew an annual pay of Rs. 82 millions as against Rs. 39 millions drawn by 162,775 Indian officers and soldiers. Even allowing for a higher rate of pay to Indian officers and retaining a large British officer-personnel, it is possible, with the same total expenditure, for India to have an army three times its present size if it was made Indian in composition.

In addition to such large differences in pay, the British element involves other heavy differential charges. Thus, in the same year, the kit and clothing allowances for 58,841 British troops cost Rs. 4·94 millions, while that for three times this number of Indian troops cost only Rs. 4·25 millions. The Indian Medical Services—specially maintained for British troops—has 860 officers with King's Commissions; while there are also such special additions to the expenditure such as those on military dairies, chaplains, hill sanatoria and depots, educational and institutional establishments of a special character and contribution to 'National' Health and Unemployment Insurance Funds.

Indianisation can, therefore, effect a large reduction in military expenditure without affecting efficiency.

Post-War growth.—The two items mentioned above operated even before the War. We must now take into account the further fact that the post-war expenditure on the Army has increased enormously as compared with its pre-war level. To quote Sir Walter Layton: "Again, the total is not only high in itself and as compared with other countries, but it has also greatly increased as compared with the pre-war situation. India, in fact, has not obtained any relief from the greater sense of world security, which has succeeded the World War. On the contrary her defence expenditure has risen even after allowing for the rise in prices and has grown more rapidly than in other parts of the Empire."[1] To-day prices have fallen below the pre-war level, and yet expenditure on defence is nearly 80 per cent. higher. This is not merely due to an enormous increase in the pays and allowances of troops after the war; it is also due to a mad search after a super-efficiency on the part of the Army Authorities in India. As the Army Sub-Committee of the Central Retrenchment Committee (1931) observes: "Efficiency must have meant to the military admi-

1. Simon Commission's Report, Vol. II, p. 217.

nistration, fresh from the experience of the great war, standards higher than those that may be considered necessary to-day. Immediately after emerging from the war, it was probably forgotten that any peace system which is not extravagant in establishment must necessarily be profoundly modified to meet abnormal emergencies and that the peace system can only be adequate for the ordinary purposes for which the Army in India is maintained and the normal contingencies which it may be expected to meet."[1] There is, therefore, room for reduction in expenditure even if the Army were to retain its present numbers and the existing British element.

It is not only expenditure on defence that is inflated on account of non-military reason; civil expenditure as well—the maintenance of an administrative framework—costs much more in India, not only with reference to Indian standards of life but also with reference to what the members of the Superior Services would get in alternative occupations. If the criteria laid down in the evidence of the Controller of the Establishments Department of the Treasury and endorsed by the Tomlin Commission on Civil Services[2] were applied to Indian salary scales, the Government of India would stand convicted of an unnecessary extravagance. Even admitting that the salaries at present paid to British members of these services were 'economic', their influence in raising the salaries of their Indian colleagues in the same services above the economic level and similarly affecting employment in the higher grades of all semi-public services is undesirable. It cannot also be denied that the continuance of British recruitment has reference not so much to administrative efficiency as to the '*political*' need for a reliable cadre in times of constitutional breakdown.

Now, under an Indian Government, the people expect these evils to be corrected and they believe that a Federal Chancellor will be able to find money for the social services by economising on these 'essential' services without disturbing their efficiency. This he can do, for the present military and civil framework of the Indian Government is extraordinarily expensive, both absolutely, and even more so, relatively to Indian needs and standards of living. And yet that is precisely what the new Chancellor cannot do under the new constitution. Defence is a 'reserved' subject and the military budget is non-votable. The salaries of the civil and other services are guaranteed, and British recruitment is to continue for the civil and the police services.[3] The Indian Government cannot even abolish posts—however unnecessary they may be—if those posts happen to be in the civilians' preserves. Under the circumstances, of course, it would be impossible for the

1. Interim Report, 1931, p. 8.
2. Pp. 83-84, Report.
3. A statutory enquiry is promised after five years.

Federal Government to surrender income tax and salt to the provincial governments; the provincial governments cannot, therefore, increase their expenditure on education or medical relief; and the people will find that they have obtained under the new dispensation no material difference to their circumstances and, being as realistic as Sir Samuel Hoare, they will find but a poor compensation in the no doubt entertaining but slightly vacuous picture of an *Indian* Federal Prime Minister and eleven *Indian* Provincial Prime Ministers. Tightening of the belt is no answer to a hungry stomach. England will not have solved her Indian problem by this financial settlement.

What we would like to suggest, of course, would be the transfer of power without any of these safeguards. It is always a good policy, when you are giving, to give generously. But since safeguards have become to the simple-minded Englishman almost the only thing he has been told about the White Paper, it might be rather shocking if he finds them suddenly removed. But it must be realised that the safeguards are the result of British distrust of Indian good faith, and they are inflicting on the Indian Budget an expenditure which is unnecessary for Indian purposes and which—what is even more to the point—the Indian budget cannot afford to bear. We suggest therefore that the expenses of the British portion of the Indian military budget should be borne by the British exchequer. We estimate this figure to be between £ 16 and £ 17 millions.[1] The Englishman can, by such a financial settlement, not only feel generous and charitable, but he will also have the righteous satisfaction of knowing that he is paying for his own idea, and he will also know that he can stop paying as soon as he gives up the safeguards. Besides, the British Army in India gives him trained soldiers in place of raw recruits and has in the past served to get commissions for poor but competent fellow countrymen of his. Finally, if some such financial arrangement is not made, the Federal Chancellor will never be able to balance his budget, and he will certainly never be able to surrender any resources to the provinces. Altogether, if His Majesty's Government *will* give India self-government and yet hedge it with safeguards that are not only politically nauseating but economically expensive, they may as well pay for their political prejudice. Not the least important argument in defence of our scheme would be the argument of placing the responsibility of paying on those who are spending the money. The Secretary of State for India became quite a popular topic in the House when his salary

1. This estimate is based on a careful study of the detailed figures under the different budgetary heads of the Final Budget Estimates of Expenditure on Defence services for the year 1933-34 (published by the Government of India). The figures given in the text refer to the year 1932-33.

was placed on the British estimates; similar salvation might await the Indian military budget when a part of it is placed on the British estimates.

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APPENDIX

A note on 'The Federal Forecast' made by the Percy Committee.

The Percy Committee compiled a federal budget showing an estimated surplus of Rs. 45 millions, with an expenditure of Rs. 801 millions as against a revenue of Rs. 846 millions. The revenue estimates were made up as under :[1]—

		(Millions of Rs.)
Customs	Net	503·0
Salt	"	55·5
Opium	"	·5
Railway	"	50·0
Currency and Mint	"	38·0
Income Tax	"	172·0
Miscellaneous ordinary		16·6
"	Reparations	3·0
State Contributions		7·4

In Appendix I to their Report, the Committee go into the details of their estimates and point out that their figures are based on

(1) Rates of taxation as levied by the Finance Act of 1931.

(2) Expectation of a restoration of trade and other economic Conditions to pre-1929 level.

(3) Separation of Burma.

It seems to me that proceeding on their own assumptions, the committee's figures under some heads require revision.

Customs :—

Let us proceed on the basis of pre-1929 volumes and 1931 rates: the total yield would then be, taking the budget expectations from the increase in rates,[2] Rs. 655 millions, made up as under :—

1. Report, pp. 4-5.

2. It may be objected that the budget estimates for 1929 were low; but the revised estimate of 1929 did not show any appreciable difference as compared with the budget estimates for that year; then again, the budget estimates for 1929 must have been based on the revised estimates of 1928, and 1928 was a particularly good year. Moreover, one cannot base, for India, revenue estimates on the basis of a bumper year.

	(Millions of Rs.)
1929-30—Budget Expectations	512·1
1930-31—Budget estimates from increased taxation	42·6
1931-32—Budget estimates from increased taxation	93·2
Addition to Budget estimates from increased taxation for 1931-32 by $\frac{1}{14}$ to allow for the fall in the revised estimates for 1930-31	6·6
Total	654·5
Deduct—Loss due to Separation of Burma ...	49·8
Net total	604·7

The rates of duties in 1931, however, were high and showed a tendency to diminishing returns. Thus, while the value of imports fell in 1930-31 and 1931-32, 31 per cent. each time, the fall in the revised estimates of revenue from customs as compared with budget estimates was by 18 and 14·4 per cent. respectively. Even this percentage fall is not quite a complete picture, as a fair proportion of import duties in India are '*specific*' and the volume of trade had not been affected quite in the same way as the value. In estimating revenues on the basis of the 1931 rates, therefore, it is necessary to make some deduction on this amount. A reasonable amount would be Rs. 35 millions. Then again, it must be remembered that of the remaining Rs. 570 millions, Rs. 210 millions would be receipts from special protective duties; but obviously, it is impossible to expect the imports of protected commodities to remain constant in volume, on a moderate estimate. We may deduct on this account Rs. 65 millions or about 31 per cent. of the receipts from protective duties. Two further deductions remain to be made. The cost of collection is Rs. 9 millions, while an amount of Rs. 11 millions is credited to the Road Fund from the customs revenues.

The net receipts from customs which can be expected is, on a fairly liberal estimate, Rs. 485 millions.

Currency and Mint :

The Percy Committee expects Rs. 30 millions under this head. No explanation is given as to how the Committee arrives at this huge net total. The average revenue from this head for the five years ending 1929-30—a representative period—was only Rs. 27·8 millions; and the whole of this will not accrue to the Federal Government, for the Reserve Bank will claim a part as its share. Even the Government of India were frankly sceptical as to the assistance which this

item could afford to the central revenues.[1] Even if we are very liberal and deduct only Rs. 10 millions as due to the Reserve Bank, the remainder left as net receipts under this head is only Rs. 18 millions.

Miscellaneous Items :

The second item under this head is Rs. 3 millions on account of Reparations; but in view of recent developments, it will have to be omitted in reckoning Federal revenues.

The first item under this head—designed 'ordinary'—is expected to yield normally Rs. 16·6 millions, and no explanation is given as to how this figure is arrived at. The average figure under this head for the five years following 1925-26 was only Rs. 7 millions. We are, therefore, reducing this figure by Rs. 8 millions leaving a remainder of Rs. 8·6 millions as expected under 'ordinary miscellaneous revenue'. The total deductions that I make on the Percy forecasts of Federal revenue are as under :—

	(Millions of Rs.)
Customs	18
Currency and Mint	20
Miscellaneous items	11
Total ..	49

To be quite on the safe side—the safe side in this case being a liberal estimate of revenue receipts—I shall reduce my own figure by Rs. 5 millions; that leaves a total of Rs. 44 millions by which the Percy forecasts will have to be reduced; leaving a total of Rs. 802 millions as estimated Federal Revenue as against an estimated Federal Expenditure of Rs. 801 millions.

But these figures omit to take into account certain recent events. His Majesty's Government have decided to create two new provinces —Sind and Orissa—involving a Federal subvention of Rs. 20 millions, and thereby increasing the estimated Federal Expenditure to Rs. 821 millions.

1. "The propriety of treating the present receipts as normal revenue may well be regarded as doubtful, and we feel definitely that it would be improper to treat it as a source which could be drawn upon in order to surrender central revenues to the provinces. The difficulty will become more clearly apparent when a Reserve Bank comes into existence. Under clause 46 of the Reserve Bank Bill of 1927, the central government was, it is true, to be entitled to a share in the profits of the bank both during the period when it was building up its reserves and afterwards. The profits, however, would be much less than the interest we now take to revenue, and, in addition, the Government of India would, under the Reserve Bank Scheme, be left with the responsibility for the disposal of surplus silver, so that any profits might be far more than swallowed up by losses on these sales."

pp. 55-56, Cmd. 3700—1930.

At the same time, the Federal Revenues estimated by the Percy Committee will have to be reduced. The White Paper provides for the transfer to Bengal of half the proceeds of the export duty on jute, which will reduce the Federal revenues by Rs. 23·3 millions;[1] it also provides for the transfer to the provincial governments of one half of the receipts from the personal income tax; this will reduce the Federal revenues by Rs. 67·5 millions. The revised estimates would then be

		(Millions of Rs.)
Federal Revenue	...	711·2
Federal Expenditure	...	821·0
Deficit	...	109·8

If we assume that the Federal Government retains as provincial contributions Rs. 49·3 millions,[2] then the deficit works out at Rs. 60·5 millions. The Federation, then, will start with an initial deficit of Rs. 60·5 millions. In addition, according to the White Paper, it will have to surrender within 10 years the provincial contribution and the tributes from Indian States and, furthermore, make cash payments to some Indian States as compensation for territory surrendered.[3] This works out to a total of Rs. 60·4 millions made up as under:—

		(millions of Rs.)
Provincial Contributions	...	49·3
Contributions from Indian States	...	7·4
Cash Compensation to „ „	...	3·7

Applying the proposals of the White Paper to the situation discovered by the 'fact-finding' committee in Indian Federal Finance, it seems that the Federation will start with an initial deficit of Rs. 60·5 millions and will find its burden increasing within ten years by Rs. 60·4 millions. Nor can the provincial governments meet this deficit, for they will just be balancing their own budgets. The position appears hopeless, but it is the writer's opinion that the Gordian knot can be cut and it is only a drastic scaling down of the Indian military budget that can effect this.

1. In 1929-30 the export duty on jute yielded Rs. 46·6 millions.

2. It cannot retain the whole of the 67·5 millions that will be transferred; Sir Samuel Hoare has declared that the initial deficits of the provinces will be met by the Federal Government. Excluding Bengal, these deficits amount to Rs. 23·7 millions on the basis even of the admittedly conservative Percy forecasts of provincial finance (p. 5—Report). Deducting from this Rs. 5·5 millions, which they estimate would be the combined surplus of United Provinces and the Punjab, there is left an aggregate of Rs. 18·2 millions which the Federal Government will have to meet.

3 p. 65.—Indian States Inquiry Report. Hyderabed has refused cash indemnity and prefers a continuance of British military aid. The question of Berar was outside the scope of the Committee's term of reference. Compensation for Berar will still further increase the burden on the Federal budget.

"THE NATURE AND SIGNIFICANCE OF ECONOMIC SCIENCE"

Probably all serious students of Economics at some stage or other of their acquaintance with the Science feel a desire to write for themselves the chapters which deal with its fundamentals. It is not exactly that they believe they have got a lot of things to say which have not been said before. Rather they want to say the old things, but in their own way, and more for their own intellectual satisfaction than for the edification of others, though in the end the evangelist in them triumphs over their other self which is content to seek personal salvation.

This, my intuition tells me, is the story of the genesis of Professor Lionel Robbins' stimulating " Essay on the Nature and Significance of Economic Science". Robbins does not claim any originality whatever for the views which he has advanced. His object has been to suggest a point of view, and state,—from this point of view,—as simply as he could, "propositions, which are the common property of most modern economists."[1] The modesty of these statements should not, however, deceive the reader about the quality of the work. For, it is a work, " written by an economist for fellow economists",[2] and has to be treated with the respect which any such study merits.[3]

What then is Robbins' point of view, and what end does he seek to attain by presenting it to the learned world ? The answer to the second question is given by Robbins himself. The Essay " seeks to arrive at precise notions concerning the subject matter of economic science and the nature of the generalisations of which economic science consists," to clear up the confusion that " still persists in many quarters . . . . . with regard to the preoccupations of the economist and the nature and extent of his competence."[4] The significance of the Robbinsian point of view lies in the contention that its adoption will enable us to perform this "spring-cleaning" of economics effectively. And how thoroughly does Robbins himself carry out his mission.

1. Robbins, p. viii.
2. Robbins, p. viii.
3. The reader, if he happens to be himself a professional economist, is grateful for this mark of attention to him and his confrères. Very few people write for him to-day, while everybody,—even the serious student—is anxious to write for the man in the street. The significance of Economics, pace Robbins, is in danger of being made to depend upon the extent of its popular appeal.
4. Robbins, p. vii.

At the end of his study of the Essay the reader will find that if the author's conclusions regarding the scope of economics were accepted, a good deal of what is now considered to be the common property of most modern economists would have to be re-classified as contraband. The change from the Classical to the Robbinsian, or rather Austrian point of view[1] does not mean merely that we look at the same collection of objects, though from a different angle of vision; it implies that we may have to regard an assemblage, which is, in part at least, different in its composition. "The nature and significance of economics" as outlined by Robbins is thus not only a challenge to the Classical tradition which reached its highest integration in the works of Alfred Marshall; it is also a demand for a reconsideration of the contents of that science.

The Classical tradition in Economics has developed round about two assumptions. The first and fundamental assumption is that economics is concerned with the question of the welfare of men and women living in organised society. "..... in the sciences of the human society, be their appeal as bearers of light never so high, it is the promise of fruit and not of light that merits our regard."[2] "Wonder," declared Carlyle, is the beginning of philosophy. It is not wonder, but rather the social enthusiasm which revolts from the sordidness of mean streets and the joylessness of withered lives, that is the beginning of economic science."[3]

The second assumption which is really a corollary to the first, but which has not been always so explicitly stated is that, since economics is only one among a number of social sciences engaged in the study of the means to human welfare, it should develop in such a fashion that it can always readily assume its rightful place in their society, and that its conclusions can be ultimately brought into relation with those of the other studies in terms of some common content of human welfare.

These two assumptions have decided for economics, as it has developed under the English Classical tradition, the choice of both its contents and its essential form. With respect to its contents, whatever affects that part of welfare which economists, *for reasons of convenience rather than those of logical precision*, have demarcated as economic welfare, lies inside the scope of its investigation. As regards the form of the science, it belongs to the category of the realistic sciences, Physics, Chemistry, Biology, etc, those which are concerned with actualities, and not to the rank of the Pure Sciences, Formal Logic and Pure Mathematics, whose function is to discover implications. Economics, according to the Classical view, is a realistic social science which investigates the causes of economic welfare.

1. Robbins' credo is Austrian.
2. Pigou, A. C., *Economics of Welfare*, p. 4.
3. Pigou, op. cit., p. 5.

But in the opinion of Professor Robbins this definition of economics is hopelessly inadequate and inappropriate. "......... it is seen to possess deficiencies which, so far from being marginal and subsidiary, amount to nothing less than a complete failure to exhibit either the scope or the significance of the most central generalisations of all."[1] It "misrepresents the science as we know it".[2] It is misleading and has actually misled eminent economists like Edwin Cannan[3] and Josiah Stamp[4] into making inconsistent and logically unconvincing statements. It has been the cause of the uninformed or misinformed criticisms of the "more neurotic critics of Economics," Ruskin, Carlyle and such like,[5] and so on and on. (Could anybody collect a more formidable armoury of offensive weapons against traditional economics !)

However, according to Robbins, it is still possible to rescue economics from this unenviable position by formulating "a definition which is free from these strictures." The clue to this definition is suggested by the fact that while the "ends" of life are multiple and various, the means at our disposal for achieving them are limited, though capable of alternative application, so that "if we choose one thing we must relinquish others which, in different circumstances, we would not wish to have relinquished." Man driven out of Paradise is thus faced with the eternal and ubiquitous problem of adjusting scarce but adaptable means to a variety of competing ends. This is the subject matter of economics, " the science which studies human behaviour as a relation between ends and scarce means which have alternative uses."[6]

Economics is, however, concerned with neither the ends nor the means as such. "It assumes that human beings have ends in the sense that they have tendencies to conduct which can be defined and understood."[7] But it is entirely neutral between them. It "cannot

1. Robbins, p. 5.
2. Robbins, p. 21.
3. Robbins, pp. 7-27.
4. Robbins, pp. 28-29.
5. Robbins, pp. 24-26.
6. Robbins, p. 15.
7. Robbins, p. 23. Robbins is not quite at ease with his definition of "end". He defines it both as "objective of conduct" (p. 12), and as "a tendency to conduct", assuming implicitly that an objective and a tendency are one and the same thing. In one place he consciously adopts behaviouristic terminology and unconsciously "the psychological doctrine of an atomistic plurality of psychic ends". In the Crusoe economy, says Robbins, "Conduct is the resultant of conflicting psychological pulls acting within an environment of given material and technical possibilities." (p. 34)

pronounce on the validity of ultimate judgments of value."[1] Hence "the habit prevalent among certain groups of economists, of discussing 'economic satisfaction' is alien to the central intention of economic analysis."[2] Similarly, its conception of an economic good is purely formal. "Thus wealth is not wealth because of its substantial qualities. It is wealth because it is scarce."

It is the relationship between ends and means conceived in this fashion which constitutes the fundamental category of Pure Economics; and from it are derived the various propositions that make up the corpus of this branch of knowledge. But a system of "given" ends presupposes the existence of a social order, with its scales of relative valuations, its distribution of property, its legal and political framework, all of which affect the disposal of scarce means for the achievement of the ends. Hence economic analysis "assumes the whole structure of 'historico-relative' psychology and institutions."[4] This assumption, moreover, determines for scarcity economics its two main divisions. In the first place, economics can deal with the changes that take place as a result of the operation of equilibrating tendencies *within this structure.* This is the function of the Theory of Equilibrium. Secondly, it can assume changes in the given structure and describe the difference between the new equilibrium and the old. This is one of the main functions of the Theory of Variations. This classification of the main sections of economic theory replaces the older, but according to Robbins, unscientific division into the Theory of Production and the Theory of Distribution.

This bare outline of the fundamentals of Robbinsian economics hardly gives us an idea of the cleverness with which they are made use of to build up a piece of "careful intellectual architecture" with a wealth of details that bear testimony to the author's acuteness. It is not, however, possible nor urgently necessary, for us to describe and discuss the details, valuable though they are. It is sufficient if we deal with the basic assumptions, on the validity of which depends the cogency of the details. Certainly the most fundamental of these assumptions on which Robbins' economics rests are those which relate to the "ends". These assumptions have been already stated. It is now necessary to examine them.

In a sense the welfare economist too makes the same or similar assumptions. He accepts the scales of individual valuations as "the

1. Robbins, p. 131.
2. Robbins, p. 24.
3. Robbins, pp. 45-46.
4. Robbins, p. 94.

irrational element in his universe of discourse".[1] For him too the ends are given objectively; he does not examine the ethical quality of their content or the sociological basis of their forms. He takes them for granted as they are, the products of ultimate social, psychological, and biological forces, which are beyond the province of his professional competence as an economist to discuss. But at this point he parts company with Robbins. While admitting that the particular forms in which the "ends" are objectively embodied are given, the welfare economist assumes that it is possible to speak of these various "ends" in terms of some common content, *viz.*, satisfaction, or economic welfare. But he is careful to point out at once that for the purpose of his science the satisfaction of which he talks is ethically colourless. He does not presume that "the valuations of the marketplace are ethically respectable."[2]

These assumptions enable the welfare economist to place his science in its proper relation to ethics. On the one hand, economic enquiries are kept free from ethical postulates, though they may be informed with and shaped by an ethical interest. "Economics still remains the science of 'what is' as distinct from 'what ought to be', though the precise aspect of 'what is' to which it attends is determined by an interest in 'what ought to be'. "[3] On the other hand, economics is still in a position in which it can furnish conclusions which can be finally valued ethically. Surely these assumptions do not make welfare economics any more normative than scarcity economics. It is, however, true that the scope of economics defined in this fashion is necessarily vague.[4] It is also true that the attempt to maintain a fruitful contact between economics and ethics has sometimes led welfare economists to "invoke the sanctions of the one to reinforce the conclusions of the other."[5]

Should we, however, because of this imperfection and this possible danger of confusing the ethical with the economic altogether reject the Classical outlook ? In the first place, is it worth while demolishing the old structure in the interest of the so-called logical precision and compactness of Pure Economics ? Secondly, is it possible to achieve this logical precision by adopting the formalist definition of economics ?

Robbins has nowhere in the Essay positively addressed himself to the first question. He is far too concerned with pointing out how economics should be made independent of ethics, psychology, and technology, to be able to consider calmly whether this crusade in the cause of precision may not take economics out of living contact with other

1. Robbins, p. 115.
2. Robbins, p. 133.
3. Young, A. *Economic Problems, New and Old*, p. 237.
4. Cannan, E. *Wealth*, pp. 17-18.
5. Robbins, p. 134.

social sciences. After all, the different social sciences must be concerned with human welfare; and though the aspects of that welfare chosen by them for study are different, their conclusions must be capable of being ultimately evaluated by a common standard, viz., our current conception of social good. It is difficult to see how economics, defined as a purely formal science of implications, can furnish conclusions of this nature. Such an economics may extend our perceptive apparatus, and provide us with a technique of rational action within the conditions of any problem posed for us. But it cannot yield conclusions which can be brought into relation with those of the other social sciences; for while it "focusses attention on . . . . the form imposed" upon human behaviour "by the influence of scarcity",[1] to the other social sciences the forms are of interest only to the extent to which the imposition of any particular form or forms affects the substance of social welfare.[2]

Secondly, it is absurd to contend that because the juxta-position in which welfare economists seek to maintain ethics and economics sometimes lead to unlawful intrusions of the one into the realms of the other, there should be no possible way of establishing contact between the two. It is not enough to desire greatly with Robbins that "economists should have speculated long and widely on ethical questions".[3] It is not even sufficient that economic enquiries should be inspired and shaped by an ethical interest. It may be necessary to establish an even more intimate relation between them. The economist may sometimes require to borrow from ethics postulates on which he can base further extensions of his science. This is essential if economics is to develop into a type of science which can be the basis of an art. And this is also legitimate, so long as it is made clear, first, that the assumption in question is not an economic assumption, which can be proved or disproved by means of ascertainable facts, but is one borrowed from the current theory of ethics or metaphysics, and secondly, that this assumption is not inconsistent with the assumptions of the science itself, and finally, that the validity of economic conclusions based on it depends in the end on an acceptance of the validity of the assumption itself.

An eminent example of this type of borrowing is found in the Theory of Public Finance. A large portion of that theory rests upon an extended application of the Law of Diminishing Utility which has

1. Robbins, p. 16.

2. This does not in the least mean that the welfare economist is preoccupied with satisfaction, the end-product of economic activity. But his study is so directed that its conclusions can be readily stated in terms of this end-product.

3. Robbins, p. 133.

been made possible by the use of an ethical postulate, viz., that men placed in similar circumstances are capable of equal satisfactions and should be, therefore, equally treated. The Law of Diminishing Marginal Utility states that the more one has of anything, the less one values the additional units thereof. Hence the more real income one has, the less one values additional units of income. The Law apparently relates to the experiences of individuals singly. It does not at all *by itself* imply that if A has more real income than B, the marginal utility of income to A would be less than the marginal utility of his income to B. If, however, we assume as a postulate of our current social theory of Democracy[1] that B is as capable of enjoying a given real income as A, then A's larger income means smaller marginal utility than B's. And if it is desirable to maximise the sum of individual satisfactions —their comparability has been already presumed—then a portion of A's income should be transferred to B.[2]

It is apparent that this conclusion contains an element of conventional valuation, and to that extent it is not purely "scientific." But should we, just because of this, exclude it from the corpus of economic science? Is it worth while making economics a pure science at the cost of denuding it of such generalisations? The answer given by welfare economists to this question is threefold. In the first place, he considers it absurd to refuse to extend the *application* of economic propositions with the help of the postulates of current ethics, when he knows that such postulates do influence our economic activities, our social relations, our ends, our happiness, in short our lives in their various aspects. Secondly, conclusions of social sciences must be finally valued ethically. This will not obviously determine their "scientificness"; but it will decide their relevancy for human interest. If this is proper, is it unreasonable sometimes to introduce ethical assumptions at an early stage of economic analysis and thereby make it possible for economics to establish further contact with real life? Finally, though these assumptions may not be needed nor implied by the theory of equilibrium, there is no harm in incorporating them in the body of economics, so long as the conclusions founded on them are not inconsistent with those of the equilibrium theory, and so long as the economist is aware of the element of conventional valuation which they contain.

We then turn to the second and more important question. Does the Robbinsian view of economics with its assumptions enable us to achieve true logical consistency for the science? As we have seen,

1. We do make such assumptions in real life. See Robbins, p. 124.

2. But even with this extended application, the Law of Diminishing Marginal Utility does not necessarily sanction progressive taxation. See Pigou, *Study in Public Finance*, p. 106.

the vagueness and the irrelevancies of traditional economics are, according to Robbins, due to its adoption of economic welfare as the unitary end of economic activities. Robbins therefore takes pains to emphasise the independence of his economic analysis of any such assumption. " The metaphysical conception of a unitary end of conduct may or may not be valid. In economics we are not concerned with these ultimates."[1] Hence Robbins defines ends as objectives of conduct which are various and "given", so to say, independently of one another. Moreover, he claims that "such a definition .... entirely removes our conception of an end from the realms of the metaphysical." But all this is hardly convincing. In the first place it is obvious that Robbins is as much making an assumption regarding ends as the welfare economist, the difference between them being that while his ends are plural and atomistic, the ends of welfare economics can all be subsumed under the common heading of economic satisfaction. Secondly, is it possible to make a fundamental assumption regarding ends—and all assumptions with respect to ends are fundamental—ametaphysical by simply refusing to concern oneself with its metaphysical validity.[2]

In fact one can discern in Robbins the tacit assumption of a unitary end of all economic activity, viz., economy or the securing of given ends with the least means. It is this which makes economics "the symbol and safeguard of rationality in all social arrangements". But Robbins does not pause to consider whether this "symbol and safeguard of rationality" is a universally accepted end of human life. One knows of scores of people, e.g., artists, who scorn to adopt this symbol and safeguard of rationality in the arrangement of their private lives, and if given their way, possibly in the arrangement of social life too.

Let us, however, grant Robbins what he has explicitly claimed for economics, viz., a multiplicity of both ends and means. But this concession at once raises some very fundamental difficulties. According to Robbins "the criterion of economy .... is the securing of given ends with the least means."[3] Now this is a perfectly intelligible criterion so long as we are trying to adjust a single given means to a single given end, or, a number of given means to an equal number of

1. Robbins, p. 23, footnote.

2. In the Preface Robbins expresses a modest desire "to keep as close to the earth as possible," to limit himself to the province defined by his "professional competence" as an economist. But is this modesty compatible with the high ambition to change the whole outlook of his science by a change in its philosophic assumptions ? Robbins seems to be arguing like the ordinary businessman who boasts of his "independence" of Economic Theory, while he is always acting on some theory or other, though, generally speaking, it is not clearly conceived and is at least a generation behind times.

3. Robbins, p. 129.

given ends, but severally. But then there is no economic problem in the situation; the problem is technical. The economic problem emerges only when we are faced with the task of adjusting a variety of scarce but adaptable means to a variety of discrete ends. What is the criterion of economy in this situation? The phrase "the use of the least means" does not enlighten us very much. In the first place, the existence of multiple atomistic ends being granted, the ends can be 'given' only qualitatively and not quantitatively. If the ends are given both qualitatively and quantitatively, then the problem of adjusting means to ends is an "administrative" problem and not an economic problem. If Crusoe's problem was to fence a plot measuring, say, 64 sq. ft *and* to keep his fire burning for, say, 8 hours in the day with wood that was just sufficient for the two purposes taken together, then it is obvious that he was not facing an economic problem. The economic problem emerged only when Crusoe found that the wood at his disposal was not sufficient for fencing 64 sq. ft of ground *and* keeping the fire lit for 8 hrs., and he had, therefore, to consider whether he should use the existing stock for more or less of fencing or fire-lighting, or whether he should get more or less of wood for use, more or less, in the same or in different proportions, in the two ways. Obviously enough, Crusoe could not solve these—the true—economic problems by the simple criterion of "the use of the least means". Before that criterion could be applied, he had to "equate" the different ends at the margins in terms of some common content of these ends just as he had to reduce a number of objectively diverse means to some common denominator, i.e. their labour contents. But now we have come back to the fundamental assumption of Classical economics and re-entered its fold after a long, but not fruitless, wandering.

D. GHOSH

FOREIGN BORROWINGS, BARTER TERMS OF TRADE AND PRICE-LEVEL IN INDIA: 1898–1913*

The foreign borrowings of India during the pre-war period of the gold-exchange standard was one of the factors responsible for disturbing the even balance between her credit and debit obligations. During that period the capital imports of India amounted to Rs. 16,302 lakhs. According to theory the disturbance, caused by any such factor of sufficiently long standing, in the even balance between the credit and debit obligations of a country on a gold standard basis is automatically adjusted. The first instalment of remittance to the borrowing country comes in the form of gold. This adds to the spendable income in the borrowing country and raises the general level of its prices. Of the prices of different classes of commodities, those of the imported commodities—imported from the lending country—fall, the prices of the domestic commodities rise and the prices of the exported commodities show a movement similar to that of the domestic commodities. The imports of the capital borrowing country increase and exports decrease till the resulting unfavourable balance of trade equals the annual amount of its borrowing.

An inductive study of India's foreign trade during the period 1898 to 1913 shows that the adjustment of disturbances was equally automatic even under a gold-exchange standard. However, in this case changes in the sectional price levels did not bring about the expected results. The rise in the prices of exported commodities did not have its usual restrictive effect on the volume of Indian exports. On the contrary, simultaneously with the rise in the prices of exported commodities the volume of exports was increasing. The explanation of this apparent inconsistency is in the fact that side by side with the foreign borrowings of India there was another factor in operation, viz., an increasing demand for India's exports. A realization of the part played by these two factors helps us to throw light on the currency controversy of the period, 1898 to 1913.

Almost all writers on Indian currency have attempted to analyse and discover the causes of the rise of prices in India during 1898 to 1913. It appears, however, that the primary objective of quite a large section of these writers was to discredit the gold-exchange standard

*This article is based on a chapter of the auhor's thesis entitled "India's Balance of Indebtedness: 1898–1913," accepted for the M. A. Degree of the Bombay University.

which was brought into operation in India in 1900. The rise of prices in India between that year and 1913–14 has been put forward by them as a definite proof of their contention that the gold-exchange standard was less automatic in its functioning than the full gold-standard, that it left to the Government which managed the currency organization, a large scope for manipulation and that while it provided plenty of openings for the volume of currency circulation in the country to expand, it did not afford any means by which it could be contracted automatically. In short, it has been maintained that the inflation of currency, the immediate cause of the rise of prices was made possible by the new monetary system which was managed by the Government and that it would have been impossible had there been a gold-standard and a gold currency instead of a gold-exchange standard with token rupees in circulation. As Professor Nicholson, the foremost critic of the gold-exchange standard system in India puts it: " In the case of gold, there are natural economic forces which in time must limit the monetary supply and so far the level of prices." Thus the whole problem of Indian price level during the pure gold-exchange standard period has been assumed by these writers to be essentially connected with the particular type of monetary organization adopted by the country. Foreign borrowings and the increased volume of our exports during the period have not been given any consideration whatsoever as factors affecting the currency circulation in India and consequently the level of prices.

To substantiate their contention these writers further compare the change in the price level in India with that in British price level during the same period, and point out that the former rose much more than the latter. But the fact that the Indian prices rose relatively to the British during the period, while it suggests that the divergence might have been due to the different currency systems obtaining in the two countries, does not at all prove it. Had it not been for their preoccupation with the alleged defects of the Indian currency organization, these writers would have looked for less plausible but more reasonable explanations of the divergence. During the period 1898 to 1913 India was a capital importing country while Great Britain was a capital exporting country. This difference in the international position of the two countries was itself sufficient to bring about a divergency of their price levels.

The trend of prices in Canada and the United States of America lends support to this contention. Both these countries were on the gold standard and yet their price levels rose much more than British prices during 1898 to 1913. Here the explanation has been found in the different positions occupied by these countries in the international capital market—Canada and the United States of America were borrow-

ing heavily from Great Britain. Whatever the system of currency obtaining in a country an import of foreign capital is bound to raise its prices. Therefore the divergency beween the prices ruling in India and Great Britain, cannot be attributed to the different currency systems of these countries. It was essentially due to their position in the international capital market and hence cannot be invoked to prove the merits or demerits of a particular system of currency.

Another explanation of the rise of prices in India during the pre-war period, without reference to the particular currency system which existed in the country can be found in the increased foreign demand for her exports. Sir J. C. Coyaji has developed this point. He maintains: "Whatever might be the currency system of a country, large gains from international trade make a country of higher level of incomes and under certain circumstances (*e. g.*, inefficiency of labour in certain directions or prevalence of diminishing returns) of high prices. These factors would be sure to affect prices even under a gold standard system especially in an undeveloped country like India producing mainly raw materials of industry which are subject to the Law of diminishing returns."[1] As we know, due to the general business prosperity of the world and the industrial expansion of a great many countries, the demand for India's export commodities, mainly raw materials, increased rapidly between 1898 and 1913. This increasing demand for exports raised their prices and the tendency of their prices to rise which reflects the intensity of the foreign demand was kept up till the outbreak of the War. Naturally, India's gains were very large. First, the volume of her exports increased and secondly her export commodities were sold at an increasing level of prices. The large favourable annual balances of trade which were the direct result of this advantageous position of India in the international market, were liquidated by the sale of Council Bills. On presentation to the Indian Treasury Office these bills were cashed in rupees which constituted additions to the volume of currency circulation in the country. Since additions to the currency circulation in India during the period of the gold-exchange standard were made chiefly by means of Council Bills, writers on Indian currency who maintain that there was inflation of currency attribute the phenomenon to the unusually large sale of Council Bills by the Secretary of State. But the sale of Council Bills was only the mechanism by which the impact of outside international forces was being transmitted to the various parts of the internal economy in India, chiefly to the price organization. The demand for Council Bills was really a demand for purchasing power in India,

1. J. C. Coyaji—*The Indian Currency System, 1835-1925*, p. 160.

which was created not by the management of her particular currency system, but by her foreign borrowings, and still more, by the increasing international demand for her exports. So long as these factors were active, their influence would have been felt upon the Indian price level, irrespective of the monetary organization obtaining in the country. And if this is a rational and sufficient explanation of the phenomenon under discussion, surely, to establish the statistical fact that Indian prices rose more than the British prices during the pre-war years, does not prove the contention that the greater rise of the Indian prices was in any way due to the peculiarity of the Indian currency organization.

In fact this rise in the general level of prices in India may even be considered as an indication of her prosperity. For, the higher level of its prices was the direct result of her increased purchasing power which was due not to any currency manipulation by the Government but was the natural consequence of her foreign borrowings and her advantageous position in the export trade. Compared with the prices obtained by Indian exporters the prices of articles imported by them were considerably less. Thus they could obtain more of the imported articles in exchange for each unit of their exports than they did before 1898. In other words the barter terms of trade were changing in favour of India during the period.

It is evident then that the true causal sequence during 1898 to 1913 ran from the growing and intense foreign demand for a number of Indian products supplemented by foreign borrowings, through an increase of currency to the general rise of prices in India. The main factor in the situation—the advantageous position which India occupied in her foreign trade—was steadily becoming more conspicuous, through more than a decade of the world's commercial and industrial prosperity.

Y. S. PANDIT

CO-OPERATION IN THE CANAL TRACTS OF THE DECCAN.

Co-operation in the Deccan canal areas offers problems which are unique for their peculiarities and well known for their complexities. Here we have an area different from the normal tracts or from the dry tracts which are not dependent upon perennial irrigation. The problem of continuous and abundant water supply, so essential for agriculture, does not arise in these areas as it does in the dry tracts. But its place is taken up by various other factors which are unknown to the cultivators in unirrigated tracts. The chief peculiarities of co-operation on the canals are mainly three, viz:—the special system of finance which in its method and scope differs essentially from other areas, the peculiar causes of overdues which are unknown in other tracts, and the general problem of stagnation in the development of co-operation so strongly visible since the last many years.

There are three big canal areas where co-operation has been introduced to a great extent and these are the Nira, Pravara and Godavari Canal areas. The latter two are in the Ahmednagar district and the former is in the Poona district. The most important of these is of course the Nira Canal area which extends over the Bhimthadi and Indapur talukas in the Poona District. Our examination of the problem therefore will be with special reference to the Baramati tract, which is the most important part of the area watered by the Nira Canal.

The era of canal irrigation was introduced as a result of the virulent forms in which famines have had to be faced by the cultivators of the Deccan. The Deccan famines have been so great a terror that the Government was forced to undertake the work of constructing canals as a preventive measure. The Nira canal was constructed just after the great famine of 1876, in order to relieve the great distress which had been caused by this famine. Full ten years were taken to complete the Nira Left Bank Canal. It runs through a well known famine zone of the Deccan. Irrigation here first began about 1885.

Sugar cane cultivation is the most prominent feature of the Nira Canal area but this was not so in the early days of this canal. It was introduced only gradually since in the beginning the main crops cultivated here were "grain crops" only. This can be seen from the

fact that in 1890 the acreage under sugar cane was only 675 and in 1902 it was over 5820 acres. When the policy of encouraging commercial crops was once adopted it became very difficult to stick to it continuously in absence of adequate facilities for obtaining finance. Government seem to have realised that adequate water facilities would be of no use if adequate finance was not there to induce the cultivators to grow the more remunerative crops.

For full 22 years nothing had been done to pay attention to this side of the problem. It is certain that the lion's share of the profits which accrued to the cultivators went into the pockets of the sawkars in those days. These sawkars came upon the scene and with their peculiar commercial instincts were able to become an indispensable factor in the life of the cultivator in these areas. Not only did they act as the financiers of the cultivators, but they also managed the sale of their produce and charged brokerage on the sale of jaggery as well as on the cake which they supplied for manure.

All this was perceived by the then Collector, Mr. Brander of the Indian Civil Service who noticed the enormous profits made by these sawkars.[1] He however came to the conclusion that what was needed was a state-aided Joint Stock Bank to take the place of these sawkars.

In order to meet the situation Government decided to sanction a special takavi scheme in 1907-1908, for advancing loans to sugarcane growers under the Agriculturists' Loans Act. A special officer with a small staff was appointed to work out this scheme with his headquarters at Baramati. Under this takavi scheme finance to the extent of Rs. 450/- per acre of cane and Rs. 4000/- per cultivator was made permissible. The rate to be charged was fixed at 9 p. c. A small depot was also opened for supplying oil cakes and selling jaggery. The proceeds collected through the sale of the borrower's produce were taken by Government by way of the recovery of the loans given and the balance left was handed over to the cultivator as his profits.

This scheme however does not seem to have been introduced on a permanent basis. Government, as well as some of our leading non-officials were at that time in favour of introducing a bank on lines of the Agricultural Bank of Egypt. They felt that in tracts where crops are irrigated and are valuable and certain they had the best field for introduction of large land mortgage institutions. Mr. Brander's conclusions had not been forgotten in any way. Whatever the truth, it is certain that the takavi scheme was regarded as merely experimental.

1. See Mr. Badve's *Co-operation on the Nira Canals.*

In order to replace it if possible by a Joint Stock Bank opinion of various persons was sought as to the desirability or otherwise of introducing the proposed land mortgage bank.

Co-operation had been introduced about this time but it was not until the registration of the Bombay Central Bank that Government could think of its possibilities. But no sooner this co-operative institution was founded Government decided in favour of co-operation as against the proposed Joint Stock Bank. Negotiations were opened with this bank for the formation of Co-operative Credit Societies in this tract and it was announced in June 1911 that the Government takavi scheme would be brought to a close by the end of November.[1]

This was done and 29 new co-operative credit societies in villages watered by these canals were formed in July and August of 1911. The Bombay Central Bank agreed to take over liabilities for the old takavi scheme amounting to Rs. 3,38,663/-. It paid to the Government all the debts of the borrowers of takavi who had become members of the co-operative societies.

It was by such arrangement that the canal tract came under the shadow of co-operation. The old takavi scheme had become well known and hence the new co-operative panacea was moulded on more or less the same lines. The shop which was formerly run by Government as we have seen was continued but its management was taken over by the bank and it was attached to a special branch of the bank which was opened at this time, in order to get over the inconvenience caused by the delays in getting fresh advances and in remitting recoveries.

A branch of the said shop and a branch of the bank were opened at Nira, a few miles from Baramati in 1914 and 1923 respectively. The Directors of the bank accepted responsibility for the expense and management of the Baramati branch and shop. It was also agreed to pay over at the end of every year 50 per cent. of the profits of the shop to the societies. Government allowed the services of the Special Mamlatdar Mr. R. B. Badve who during the next four years was of the utmost use to the societies.

In 1912 there were 29 societies with 2,085 members. The very first year's progress of these newly formed societies was by no means discouraging as the following will show :—

1. Badve's *Co-operation on the Nira Canals* (Report).

Figures showing progress of the Baramati Branch in 1912.

Receipts	Rs.	Disbursements	Rs.
Loans borrowed from the Bank	5,80,283	Loans repaid to the Bank	1,21,625
Loans repaid by members	1,21,625	Loans advanced to members	5,80,283
Interest received ...	3,120	Interest paid	2,376
Entrance Fees ...	2,092	Cost of management ...	2,047
Total	7,07,120		7,06,331,
		Cash balance ...	789

Since this early beginning the movement has no doubt progressed in this tract but as we shall see below the condition of these canal societies to-day is not very encouraging. Overdues have mounted up to an enormous extent, finance has been enormously curtailed, members have not made genuine attempts to further the progress of co-operation, and looked at from all points of view the canal tracts are a source of great anxiety and care to the Provincial Bank.

This is true not only of the Nira Canal Societies but also of the societies in the Godavari and Pravara canal areas. As a matter of fact I shall show below that these latter canals present a scene of greater stagnation than the Nira canal area.

The Godavari canal was opened with the same object with which the Nira canal was constructed, viz., to fight the famines of the Deccan. But it has been more or less a latter day product for it began to supply water only in 1911.

As in the case of the Nira Canal cultivators, so also in the case of the local cultivators in the Godavari canal area the need for finance was felt very acutely. The poor and backward cultivators in the Kopargaon taluka (where this canal is situated) saw what the "malis" from Saswad in Poona district were doing in this taluka. But they could not imitate the good example because they were not able to obtain loans at less than 25 per cent. from the local sawkars. The Co-operative Department was therefore approached by Mr. C. S. C. Harrison, the Executive Engineer. Seventeen societies were organised in the year 1916-1917 as a result of the efforts of Mr. Harrison and his assistants, helped as they were by the Special Mamlatdar Mr. D. A. Patil and the Co-operative Department.

A special depot for supplying manure and for sale of jaggery was opened at the Chitali Railway station in the same year.

Though co-operation has been introduced in this way in the Nagar district as well, the tract around Baramati is of greater importance both from the point of view of the quantity of business done as well as from that of the slow, but perceptible, improvement, marked in this area.

We have seen during what years the branches at Baramati and Nira were opened. We shall now see how far these important canal societies under the Baramati Branch offer us hopes of improvement or fears of further deterioration. The Nira branch was not very important and it was closed in July 1931.

The Baramati Branch of the Bank had on 31-3-31, about 35 societies under it but three of them, viz., the Baramati Industrial Settlement Society, the Baramati Public Servants' Society and the Baramati and Indapur Servants' Society were not borrowing from the Bank, nor were they agricultural credit societies. Out of the remaining 32 societies, 22 were in Bhimthadi taluka, and about 10 in the Indapur taluka. There were about 6 societies affiliated to the Nira Branch and we shall also take them into account.

If we take into account the 35 canal societies from the Nira and the Baramati branches which are affiliated to the Bhimthadi Taluka Supervising Union we will find that they have been classified by the departmental auditors as follows :—

Audit classification of Nira Canal Societies.

A class societies	B class societies	C class societies	D class societies
1	9	21	4

There was only one A class society—the Nimbud society and there were as many as 25 societies in C and D classes. We shall see what is their position from point of view of finance received, collected and disbursed, as well as from the point of view of membership.

So far as membership is concerned not much development has taken place. This is but an index to the general stagnation. The total number of members in the 35 canal societies affiliated to the Bhimthadi Supervising Union comes to 3780 only. If we remember that the total number of members in this tract in 1916, i. e., about 16

years ago, came to 2504 and total number of societies to 28, the progress made in all these years certainly does not seem to be encouraging at all. In the Bavda Co-operative Credit Society we have only 40 members. Three societies have less than 50 members, 17 less than 100 but more than 50, 12 less than 150 but more than 100 and 3 above 150.

Though this membership analysis clearly shows that our societies have not been able to attract more cultivators due to the general stagnation, it is also clear that except in the case of three or four societies unwieldy membership is not the cause of general deterioration.

This general stagnation can also be seen from another view point —organisation of new societies since the last few years—as shown below.

Year of the organisation	No. of Societies	
1911	25	(These figures refer to the societies—organised in the jurisdiction of the Bhimthadi Supervising Union and affiliated to it.)
1915	1	
1917	2	
1923	1	
1924	2	
1925	2	
1926	1	
Unknown	1	
Total	35	

After 1926 not a single society has been organised in this tract. Out of the 35 societies as many as 25 are the old societies organised in the beginning in 1911. If the movement had been successful there is no reason why we should not have had 135 societies instead of only 35. Apart from the cancelled societies, we see that in more than 20 years we have not been able to organise even a dozen societies in this tract.

The financial status of these societies will throw further light upon their condition. There is no society that is wholly dependent on its "owned capital" alone. Out of these 35 societies there is only one that owes nothing to the Bank—the Jalochi Society—but its general condition is hopeless for it has only 79 members with a working capital of Rs. 4431 only. Its members' deposits come to Rs. 1107/-, non-members' deposits to Rs. 1150/-, reserve fund Rs. 2153/- and total outstandings from members to Rs. 4099/- only. It is not able to finance

even to the limited extent to which other societies are able to do, because it will be seen that the average amount of working capital available per head comes to only Rs. 56/– which is not even equal to the amount needed for irrigation charges, much less the amount needed for sowing, manuring, and harvesting the crop.

All the other societies are debtors to the Provincial Bank having borrowed very large sums in the past.

Some of the comparatively better societies in the tract are the following:

(1) Kamleshwar, (2) Nimbud, (3) Sangvi Hanuman, (4) Katyachiwadi, (5) Shindewadi, (6) Nirwagaj and (7) Karanje.

The following figures show their position to-day.

Society's Name	No. of Members	Members' Deposits	Non-members' deposits	Reserve Fund	Loan from Bank	Total working capital	Total outstandings of members
Nimbud (A)	124	4,997	Nil	17,116	4,266	26,577	21,363
Kamleshwar (B)	65	4,937	23	15,400	8,727	29,090	26,622
Sangvi-Hanuman (B)	105	1,913	Nil	14,316	4,943	21 355	19,312
Katyachiwadi (C)	91	5,355	1	20,150	23,909	49.415	45,513
Shindewadi (B)	40	1,621	Nil	794	2,942	6,367	5,167
Nirwagaj (C)	98	6,526	7,000	23,192	24,661	61,398	54,953
Karanje (B)	148	6,220	Nil	23,042	28,146	57,675	44,983

Even in one or two of the above the Societies, members' deposits have shown a tendency to decrease but excluding Karanje and Nirwagaj the other societies show a tendency for increase in the Reserve Fund. It is possible that some of these societies will become self-reliant in a few years if nothing untoward happens.

Dues to the Bank were decreasing gradually in Kamleshwar, Katyachi-wadi, Sangvi Hanuman and Nirwagaj societies. Members' deposits have also shown an increase in them.

The worst in the tract are, Hol, Pandare No. 2, Gunawadi, Baramati, Late, Korhale Khurd, Shiravli, Nimbodi and Sangvi Shivaji societies.

The other societies are also more or less bad and in a moribund condition though the local Union regards them as "Normal" societies. They are the Malegaon, Pandare No. 1, Bavda, Dehkalwadi, Pimpli, Medad, Khandaj, Jalochi, Shirasney, Belvadi, Sansar, Tarshi, Udhat, Lasuney, Khorale Budruk, Zargadwadi, Malad and Songaon. Nothing short of a miracle can put them on their legs again within a short time. It is also true that some of them like the Medad society have made Herculean efforts to pay back their dues to the Bank, and have succeeded in showing a decrease in their overdues but one should expect still better progress from them. The Medad society deserves attention in this respect. It had no overdues whatsoever on 31-12-31 to the Bank. But this cannot be the only test. Looked at from all points of view even such societies cannot be regarded as satisfactory. The Medad society for example has only Rs. 5568/- as its total working capital and when compared to its hundred members we can see that like the Jalochi society it can spare only Rs. 55/- per head which is quite inadequate.

The Malegaon and Bavda societies deserve special attention. The Malegaon Society was once the best society of its kind in the whole of the Presidency. Along with the Hadapsar Society it had attained an all-India reputation. It was regarded by the Registrar in 1913 as "the best managed and the most trusted." The following figures for 1921 and 1931 show that it has not been able to progress much in these ten years.

Malegaon Co-operative Credit Society

	1921	1931
Number of Members	144	160
Members' deposits	Rs. 34,694	Rs. 40,062
Non-members' deposits	„ 83,000	„ 70,860
Reserve Fund	„ 23,858	„ 3,15,082

Though these figures show that its progress has not been worthy of a society having an All-India reputation, yet they do not clearly reveal the present deterioration in the society. It is in a dying condition to-day, and its overdues have actually risen. Its Reserve Fund will have to be used up in paying off its liabilities. The Registrar had appointed an Inquiry Officer in June 1929 to inquire into the defects in the working of this society, under section 43 of the Act of 1925. This inquiry revealed defects,

There had been no internal check of the Managing Committee for years together. Non-residents of the village had been admitted as members against bye-law No. 4. Loans were advanced in excess of limits laid down in bye-law 31.

This is sufficient as an indication of the seriousness of the situation in case of this society. The non-members of the society are clamouring for repayment of their deposits. It is at present doing no other business except recovery work. The property and money of the society have been attached because of the legal steps taken by the Provincial Bank to recover its dues. In 1931-32 serious legal complications had arisen in case of this society due to its inability to repay the loans of the Bank and to return the deposits of its non-members.

The Bavda Co-operative Credit Society is another big giant lying in a moribund condition. Its working capital is equal to Rs. 2,48,890/-, which is less than the working capital of the Malegaon society which is Rs. 3,15,082/-. But it has an unwieldy membership which has made the smooth working of the society a difficult matter. This society alone shows an increase of Rs. 1,22,000/- in overdues. The society offers no hope of revival in its present condition. It had not joined the Supervising Union till 1930 and this might have been a cause of its present deplorable condition. Since it joined the Union (in March 1930) a very slight change in its position is visible. It has been proposed to split it up into other small societies and not to distribute its Reserve Fund on its dissolution. We have seen the general stagnation of the Co-operative movement on the canals. Now we shall examine a little closely the figures for total overdues in this tract. These figures will enable us at once to grasp the serious predicament in which the Provincial Bank, as the main source of the finance of these societies, must have been put to. The following illustrates this in all the three important canal areas.

Nira Canal Societies.

Year	Outstandings Rs.	Overdues Rs.	Advances Rs.	Recoveries Rs.
31-3-1927	25,02,130	10,44,851	...	...
31-3-1928	20,91,600	14,59,593	3,26,912	7,38,542
31-3-1929	19,45,249	14,74,865	1,47,996	2,95,823
31-3-1930	18,20,235	13,86,512	1,94,087	3,19,678
31-3-1931	18,07,682	15,78,527	2,14,131	2,26,688

Godavari Canal Areas

Year	Outstandings Rs.	Overdues Rs.	Advances Rs.	Recoveries Rs.
31-3-1927	5,51,165	2,08,158	...	...
31-3-1928	5,57,121	3,38,892	1,51,376	1,46,754
31-3-1929	3,17,083	Not known*	43,437	79,036
31-3-1930	3,00,229	2,30,697	26,534	41,464
31-3-1931	3,01,598	2,67,892	35,908	35,540

Pravara Canal Areas

31-3-1927	4,22,481	1,93,705	...	...
31-3-1928	4,25,760	3,05,860	83,950	76,934
31-3-1929	3,27,301	Not known*	19,979	53,046
31-3-1930	2,92,261	2,33,209	27,521	32,247
31-3-1931	2,98,079	2,49,951	49,687	20,057

Mark in the above statistics the increase in the overdues in all the three areas and a decrease in the amount of recoveries at the same time though new advances have not decreased.

Overdues have besmeared the fair name of the cultivators on these canals from the very beginning. They have in Nira Canal areas a long history behind them. Even in the very first year of the attempt made by Government before co-operation was introduced overdues began to appear. In spite of the summary powers of recovery which had been given to the Special Takavi Officer appointed by the Government overdues began to grow. Since then the tract came into the hands of co-operators but even then overdues began to accumulate. During certain periods they showed a decrease but at no time have they disappeared entirely. In 1914—not even three to four years after the introduction of the movement—they amounted to Rs. 71,990/- out of a total outstanding of Rs. 8,77,522/- and total working capital of Rs. 8,99,443/-. In 1915 they rose to

* Only the consolidated figure for overdues of this year on both Pravara, and Godavari Canal societies together is available with me. It is Rs. 5,55,356/-.

Rs. 2½ lakhs. They came down to Rs. 97,479/- in 1916, and to Rs. 66,631/- only in 1917, due to special efforts made by the Bank, the Guaranteeing Union, and other Departmental Officials. The organizational, moral and economic defects once more asserted themselves when these overdues rose again within two years. They however decreased once again and in 1922 came down to Rs. 66,000/- only, out of a total working capital of Rs. 11·3 lakhs, thus constituting only 5·5 p.c. of the working capital. In six out of the 30 societies at that time overdues were non-existent and in six others they were merely nominal. From this time however they have increased continuously.

The particularly abnormal rise in the overdues which we witness to-day is a product of the post-war period which seems to have reduced the canal areas from their pre-war and war time prosperity to utter misery. The following figures will show the unbelievable rise in overdues within a short period of three years in the Nira canal tract. (Figures are for July of every year mentioned).

Year	Total outstandings of Societies	Total overdues of Societies	Overdues to the Provincial Bank	Fresh loans made by Provincial Bank
1923-24	15,35,544	1,90,491	1,90,491	10,35,462
1924-25	21,27,434	5,29,208	5,29,208	13,00,307
1925-26	26,30,852	15,81,176	8,56,148	13,37,760
1926-27	20,99,636	19,43,818	13,01,288	...

These figures are specially given to mark the rapid rise in the overdues during this short period in the Nira Canal Societies. It will be noted that within a short period of 3 to 4 years the overdues of the societies to the Provincial Bank rose up from Rs. 1,90,491/- to Rs. 13,01,288/- an increase of about 11 lakhs of rupees all at once. The total overdues of the societies at the same time rose to an even higher figure from less than 2 lakhs to about 19½ lakhs.

The statistics given below show that at least in the Nira Canal area we do not witness that stagnation which we witness in the Pravara and Godavari canals. These figures refer to the overdues of the societies to the Bank and not overdues of the members to their societies.

Statistics showing the Increase and Decrease in overdues of Important Societies affiliated to the Baramati Branch of the Provincial Co-operative Bank.

Name of Society	Loans outstanding to the Bank on 31-3-1931	Overdues on 30-6-1929 Rs.	Overdues on 30-3-30 Rs.	Overdues on 30-6-1930 Rs.	Overdues on 30-12-30 Rs.	Overdues on 31-3-1931 Rs.
Baramati ...	28,857	27,643	26,443	26,795	24,095	24,098
Nirwagaj ...	24,661	24,496	18,639	14,237	13,737	13,774
Medad ...	339	3,307	3,007	1,807	500	300
Khandas ...	19,832	14,188	13,670	12,916	12,582	12,682
Malegaon Budruk ...	1,36,807	1,31,736	1,16,424	1,19,379	1,17,572	1,16,972
Sangvi Hanuman ...	5,098	2,013	Nil	Nil	Nil	Nil
Shiravli ...	4,174	4,740	3,518	3,518	2,368	2,368
Pandre No. 1	1,05,724	1,10,901	1,07,369	1,07,669	1,04,153	1,00,119
Pandre No. 2	97,042	85,700	89,100	98,401	1,03,737	94,387
Kameshwar	8,727	1,059	3,330	3,330	1,830	240
Shirashne ...	52,140	41,249	45,693	46,693	48,773	48,123
Malad Baramati ...	10,333	5,514	2,796	3,127	3,004	3,004
Gunawdi ...	71,356	69,546	68,146	68,114	67,714	67,214
Dorlyachiwadi ...	16,484	13,569	13,262	13,211	12,711	12,678
Zaragadwadi	16,401	8,100	6,445	6,445	6,212	5,212
Pimpli ...	10,210	3,243	7,223	6,732	6,332	5,110
Katyachiwadi	23,908	12,087	17,015	17,015	17,030	16,438
Dhekalwadi	45,718	39,453	35,547	36,242	37,584	37,184
Sansar ...	13,451	13,458	10,679	10,679	9,615	9,185
Udhat ...	55,632	538	48,670	50,279	51,147	50,090
Tawshi ...	17,778	10,217	10,785	10,160	10,060	10,807
Belwadi ...	28,149	20,296	19,418	19,418	20,801	19,996
Sangvi Shivaji ...	6,013	10,126	9,046	7,300	7,000	25,950
Nimbodi ...	24,584	25,264	25,097	26,335	24,762	24,062
Lasure ...	9,058	5,613	5,613	5,613	5,051	4,951
Kuruvali ...	4,955	5,214	4,623	4,300	4,005	4,005
Songaon ...	4,794	10	Nil	1,126	824	2,644
Kalamb ...	2,028	2,728	2,728	2,078	2,028	2,028
Shindewadi	2,942	Nil	Nil	Nil	Nil	21,902
Kanmodwadi	3,817	Nil	Nil	537	722	1,372

It will be sufficiently clear by now that though on the whole overdues do not show signs as yet of any appreciable decrease in any of the three important canal areas they are very gradually decreasing at least in the Baramati tract in case of a large number of societies.

The figures regarding the Nira Canal societies shown above clearly prove this if any proof were needed. The position however is not hopeful even to this extent in the societies on the other two canals for on the Godavari and Pravara canals, every society shows an increase of overdues.

Large amounts are involved in arbitration in these societies as a result of these extraordinary overdues. The figures given below show this fact so far as some of the important societies affiliated to the Baramati branch are concerned.

Name of Society	Amount involved in arbitration Rs.	No. of members against whom arbitration amount involved	Percentage of arrears to present outstandings.	No. of defaulters	Date.
Malad-Baramati ...	9,051	10	75·4%	28	18-1-32
Tavashi ...	6,393	8	82 5%	34	8-2-32
Nimbut ...	3,577	11	33·3%	25	5-12-31
Zargadwadi ...	3,178	10	75·%	44	3-2-32
Medad ...	3,165	11	100·%	43	16-6-31
Nimbodi ...	2,378	6	99·%	62	7-8-31
Dorlyachiwadi ...	9,028	17	92·%	45	4-2-32
Pimpli ...	9,943	7	87·%	44	3-2-32
Nirwagaj ...	11,930	9	87·7%	42	2-2 32
Sangvi Hanuman ...	3,510	12	84·3%	41	18-1-32
Sansar ...	7,605	27	95·%	71	14-2-32
Katyachiwadi ...	26,118	24	91·5%	45	2-2 32
Jalochi ...	1,827	10	100·%	31	28-6-31
Shindewadi ...	Nil	Nil	12·1%	5	28-1-31
Kamleshwar ...	1,855	2	76·7%	33	14-2-32
Karanje ...	23,915	49	86·6%	86	28 12-31
Khorale Badruk ...	32,092	20	92·1%	74	2-2-32

What are the causes of this state of affairs? How is it that the canal tract which at one time gave the greatest hopes to all should have been reduced to the deplorable condition in which it is found to-day?

The causes of overdues in the canal tracts are in some respects peculiar to this tract alone. The canal tracts have special features and special causes of overdues. Some of the causes however are common to all the tracts. Let us examine all of these causes together.

The causes of overdues in canal tracts can conveniently be classified under three broad categories:—

1. Economic causes;
2. Defects in the co-operative organisation itself; and
3. Causes due to the peculiar characteristics of the people.

All of them however are interconnected with each other, the economic causes being the most important of the three.

It has already been noticed above that though overdues have always existed in these tracts they never were so serious as they are

to-day and that the great rise in overdues to-day is a product of the post-war period. This period then has much to do with these overdues and the chief causes are a phenomena of this post-war period.

The chief cause is the phenomenal fall in the price of gul. The period of the war was a period of great prosperity to the canal cultivators. The increase in the demand for sugar and gul during the war time led to the raising of the price of both these commodities and the cultivators reaped large profits. This can be seen from a rough examination of the price of gul. Whereas the pre-war rate was something like Rs. 20/–per palla the rate during the war time rose enormously and it came even to Rs. 60/– per palla. Roughly it may be said that it varied between Rs. 40/– to Rs.60/–. This rise in the price of gul brought great profits to the agriculturists. This led to an increase in sugar cane cultivation. Lands were bought at fabulous prices with borrowed money. There was a regular competition between the bigger cultivators so far as the question of increasing the acreage of sugar cane plantation was concerned. Even defaults were wilfully made so that more lands could be bought and cultivation increased.

This era of high prices led to a great rise in the standard of living. There can be no mistake as to this. Judged from all view-points, from their dress, their mode of living, their desire for keeping ponies and even in some cases of small tongas for conveyance, a phenomenal rise in their standard of living was clearly visible.

Land values were inflated due to competition amongst them for buying more and more land for sugar cane crops. Even raw hands were tempted to try their luck and sugar cane cultivation was taken up by men who had no experience of it.

But war could not last for ever nor could the era of inflated prices. Within a few years after the close of the war, notably since 1923, prices began to fall steadily. This fall in prices due to the disappearance of the war conditions has been further aggravated by the world depression we witness to-day. Last year the price of gul was the lowest in the history of sugar cane cultivation. Unexpected as it was it has hit the cultivator a blow from which recovery cannot be quick. The market quotations showed that gul could be had even at the low price of 11 seers for one rupee.

Habit of cultivating cane has become with these cultivators almost a second nature. They have all these years gone on gambling in the hope of better prices and have spent larger and larger amounts year after year only to find now that prices are not likely to go up. They have borrowed continuously in the hope of a rise in prices and to-day they find themselves in indebtedness.

They have not been able to cut down their standard of living. It is not very easy for people accustomed to a high standard of life for a number of years together to lower it all at once. They have borrowed more and more to maintain it and consequently their indebtedness has risen.

Though this cause of price fluctuations is one of the most important of the causes operating towards overdues it is by no means the only cause. It is true that sugar cane cultivation is the most speculative of all crops and that it is dependent to a very great extent upon the price factor but the overdues of to-day are not due solely, wholly, and entirely to the price factor. There are various other economic, organisational, and psychological factors, which we will have to consider.

In the first place though prices have fallen and income from the sale of crops is decreasing yet the cost of cultivation has not appreciably diminished. This cost of cultivation consists primarily of three to four factors.

1. Irrigation charges.
2. Land Revenue.
3. Labour cost.
4. Cost of manure.

The cost of cultivation increased considerably chiefly during 1917–1918. Mr. Ewbank calculated that the cost of male-labourers had risen by 80 p. c. and of female labourers by 150 p. c., of iron ploughs and iron crushers by 100 p. c. and of gul boiling pans by 150 p. c. during 1915–1920. The cost of manure is a very important factor and the increase in this cost during this period is brought out clearly by the following :

Price per Khandi

Year	Kardi	Castor	Saffloor
	Rs.	Rs.	Rs.
1914	18	14¾	15
1915	16¼	15½	14½
1916	16¼	17	15¾
1917	18¼	16¼	15¼
1918	24¾	17	19

The following will also show the total estimated increase in the cost of cultivation per acre between 1905 and 1918 :—

Items of Expenditure	Cost in[1] 1905	Cost in[2] 1908	Cost in[3] 1918
	Rs.	Rs.	Rs.
Labour	75/-	130/-	127/-
Natural manure	75/-	80/-	83/-
Seed	50/-	50/-	75/-
Oil-cake	100/-	105/-	204/-
Water rates	25/-	25/-	48/-
Rent	15/-	9/-	30/-
Interest	68/-	33/-	40/-
Crushing charges	80/-	80/-	140/-
Total	488/-	512/-	747/-

This rise in the cost of cultivation was accompanied by a rise in prices, specially during the war time. To-day however though prices have fallen considerably, the cost of cultivation has not decreased appreciably. During the war the wages of labourers increased to even Re. 1/- per day. Similarly the irrigation cess also increased though land revenue was more or less stable. This increase in the expenses however was not felt at all in those days since prices also rose as we have already seen. But what is the position to-day ? The wages of labourers have no doubt decreased but they are still higher in comparison to the prices. To-day they vary from 7/- annas to 11/- annas per labourer. The irrigation cess too has not decreased in any way, nor has land revenue. The price of manure is also very high to-day specially when we take into account the high price paid for oil-cakes and the low price of produce sold. The experienced Senior Inspector of the Branches of the Provincial Bank in the Ahmednagar district says in his Branch Report that "the cost of cultivation, specially for oil-cakes was high while the prices of produce fell down almost to the level of prices of oil-cakes allowed last year. There could be no margin of profits."

Thus whereas during the war time we had

1. A continuous rise in prices of gul.
2. A rise in the cost of cultivation.

1. This estimate is given in paragraph 5 of Mr. Brander's Report printed in the Govt. Resolution No. 10509 of 19-11-1910. Revenue Department.

2. See para. 48 of the Report of the Special Takavi Officer in G. R. No. 10509 of 19-11-1910.

3. These estimates were supplied by Professor Knight—March 1920, Co-operative Quarterly.

3. A rise in the standard of living.
4. A rise in the value of land.

We have to-day:

1. A continuous fall in the price of gul.
2. No appreciable decrease in the cost of cultivation.
3. No appreciable decrease in the standard of living.
4. A great decrease in the value of lands.

This will make sufficiently clear the formidable combination of various factors which have made canal cultivation almost as great a gamble as cultivation in the dry tracts. If in the dry tracts profits depend mainly upon the seasonal factor, in the canals they depend mainly upon the price factor—price of cultivation, price of manure and the price of crops. In both of them it would seem that cultivation is nothing short of a gamble.

What remains now for our consideration are the defects in organisation and the defects in the characteristics of the people.

It must frankly be admitted that the co-operative organisation as evolved for the needs of the canal cultivators exhibits many grave defects. It must not be forgotten that the present system has arisen from the amalgamation of two opposing ideas. Co-operation was laid upon a soil for which the Agricultural Bank of Egypt was supposed to be necessary. Due to various circumstances it has not been possible to work the Canal societies on true co-operative lines. Some of our officials and non-officials criticised the working of the system even as far back as 1912.[1] Rao Bahadur Desai described the work of the Provincial Bank at Baramati as being "more commercial than co-operative". He objected to the Central Bank taking "mortgage promises as collateral security". Though we may not exactly agree with the views expressed by Rao Bahadur Desai in those days it has to be admitted by co-operators that our Canal societies are not working on true co-operative lines.

The co-operative system as worked on the canals to-day was not evolved on the best of lines. Mortgage security became an indispensable factor even from the very beginning. The societies have borrowed from the Bank huge amounts, and default in repayment of these amounts has led to almost a crisis. There is no loyalty on the part of the members. It must be acknowledged here that members were not chosen in the beginning with that discrimination with which they ought to have been chosen. Hundreds of them joined the societies merely because they had learnt that membership in these societies would give them access to an almost unlimited supply of capital. The

1. See criticism of Rao Bahadur A. B. Desai and of the Hon'ble Mr. Curtis in the Provincial Conference of this year.

societies are not composed of men who would be willing to repay with that enthusiasm with which they borrow. Sugar cane finance has offered one great difficulty. The period for a sugar cane crop is about 13 to 15 months and fresh loans had to be granted necessarily before the Bank could recover its previous outstandings fully. This was found to render cane finance on true co-operative lines a difficult matter inasmuch as this made it possible for the members to utilise the new amount given for paying off the preceding loans taken.

Over-financing and under financing have both been promiment defects in the working of the Canal societies. If under-financing is more prominent of the two to-day, over-financing was a greater defect in the past. It cannot be denied that there was over-financing in the initial stages. There was a case for example where a member took loans for raising a sugar cane crop when as a matter of fact the borrower had not raised any such crop.

There was no proper field inspection and finance was sometimes provided for a larger area than what was actually cultivated. There was no agency to select the best fields for the cane crop once the areas were included in the "blocks" by the Irrigation Department. The average limit at one time for miscellaneous loans was as high as Rs. 1,000/-. This would have led to proper and adequate finance provided the Bank and the societies had taken care to prevent over-financing. Indeed if under-financing is a cause of overdues, over-financing is an equally important cause because when a cultivator is given more than what he needs he will waste it on unproductive purposes and consequently we will have no means of repayment. Current accounts of societies with the Bank were freely operated upon for crushing charges and at times even double the amount of the actual charges were allowed. The absence of the Normal Credit Statement was responsible to a great extent for this over-financing. When a member wanted Rs. 1,000/-, for example, he would go to the Society and demand Rs. 2,000/-. The Society used to give him Rs. 1,500/- or so for the societies in those days thought that their existence would not be justified if at least 50 to 60 per cent. of the amount demanded was not sanctioned. The members however took care to demand at least double the sum that they really wanted. There was no genuine co-operative spirit which could teach them that they should never demand what they could not repay and what they did not need.

There was very little of true supervision. Benami transactions were not readily detected if not actually connived at in important cases. The secretaries of the societies were given commission according to the recovery effected and this encouraged them to resort to book adjustments or to the adjustment of fresh advances in repayment of

old dues. There was no agency to see that loans were exactly utilised for the purpose for which they were taken.

Thus defects in the organisation and in the characteristics of the people have also contributed a great deal to the present state of affairs. If we had honest men to work the societies, if we had cultivators who would not have shirked the responsibility of supervision and work, if we had people who, instead of regarding co-operative societies as Sarkari Mandalis, had regarded them as their own, much of the overdues we see to-day would not have disfigured this tract at all.

Another defect with some of the cultivators on the canal tract is to get all their work done by hired labourers instead of doing it themselves. I wonder why some of our cultivators should think that their main work is to supervise only and that all the physical labour involved should be done through hired labourers alone. Is there a way out of these difficulties? We shall consider some of the essential remedies.

There are important people, including even some of the Directors of the Provincial Bank, who think that Co-operative Credit Societies are not at all suited for the Canal areas. Mr. G. F. S. Collins, one of our ex-Registrars, was actually of the opinion that "it will eventually be necessary to have land banks similar to the Zamindari Banks in Sind run on strict business lines for large cultivators and that this would have been the correct policy from the beginning."[1] There are others who hold the view that such banks are necessary to-day only for the bigger cultivators and that the present day small co-operative credit societies should continue to finance the smaller agriculturists.

Though something can be done in these directions it will be necessary to solve the problem of the existing overdues before taking any other final step. We may offer a few suggestions with this end in view.

1. Firstly the Irrigation Department must try to lend a helping hand in the matter.

The Nira Canal was at first classed as a "protective work" but it was subsequently converted into a "productive work". This "productive work" idea led to the introduction of the block system. According to this system lands of cultivators are formed into "blocks" by the Irrigation Authorities. It is agreed that only one-third of this block must be brought under sugar cane crop by regular rotation, and the cultivator must pay a uniform rate of water tax for the whole area, included in his block. This is the idea underlying the present system. But in practice this has led to certain disadvantages. Under this system irrigation cess is based upon a contractual basis whereby it is

1. See Annual Report of the Co-operative Department for 1926–1927.

arranged between the cultivator and the Irrigation Department that the former must pay for a certain fixed number of years a certain sum as the cess for each acre irrigated and the latter must supply water to these lands. The difficulty is that the cultivator has to pay his cess every year as per contract irrespective of the fact whether he cultivates the land or not. It has also been detected that when land is commanded by the canal and is guaranteed a perennial supply of water, and the agriculturist has to pay the block rate every year it is difficult to prevent members of societies from growing sugar cane crops. The Bombay Provincial Banking Inquiry Committee were of opinion that suitable crops should be substituted with advantage in the place of sugar cane. But if this recommendation is to be carried out it is absolutely essential to see that the irrigation policy does not in any way prevent members from doing this. It has been noticed many times in the past and that too even by influential officials like Mr. R. B. Ewbank that the irrigation policy based as it is on the block system was actually preventing co-operative societies from following the policy of withholding loans to members who were growing cane on unsuitable land.[1]

Another unsatisfactory feature is the continuous rise in the irrigation cess. The rate for one block of three acres was Rs. 30/- in 1908, Rs. 33/- in 1910, Rs. 39/- in 1911, Rs. 48/- in 1912-1918 and to-day it is about Rs. 70/-. The present cess is very high when we look to the diminishing profits which agriculturists are getting from their lands. The profits which cultivators obtain to-day are much less than what they were obtaining in 1918 to 1919 and yet the irrigation cess, instead of decreasing proportionately, as it presumably should, has actually increased. One hears complaints that the policy of the Irrigation Department is most unsympathetic and needs overhauling. It would be better if Government were to set aside for the time their notion of getting big profits from these canals. Let us not forget that originally it was a protective work and though with changing circumstances to-day it may remain a productive one, yet the profits which may be obtained from these works must be consistent with the actual conditions prevalent in the tracts. Would it not be better for example to change the present system and charge the irrigation dues according to the volume of water consumed? This would be fair to the cultivator and profitable to the Government as well for they will be able to judge which crop pays them most.

Another fact to which attention may be drawn is the problem of water logging. The old irrigation policy was one of the causes

1. March 1920, *Co-operative Quarterly*, p. 202.

of overdues. It is really unfortunate that no systematic survey of the soil was made when water facilities were first thrown open to the cultivators. It seems water was given to all agriculturists without making a proper survey of the soil. But to-day the Irrigation Authorities have understood the value of this. No irrigation work should be thrown open without a careful survey. Absence of this careful survey at least in case of the Nira Canal was a cause of the early overdues.

Water logging is a very deplorable feature. Owing to a very easy supply of water, crops were over-watered. The soil being rather black and deep it became water logged. The irrigation authorities do not seem to have paid much attention in the early days to proper drainage of lands so watered. We have it on the authority of Dr. Mann that "Little attention was paid to drainage either by the Canal Authorities or the people, the sub-soil became more and more injuriously affected by salt, with the result that over 5,000/- acres of formerly cultivated land under the Nira Valley are now useless".[1] The negligence of the Irrigation Authorities in this connection leads to increase in the cost of cultivation and decrease in the outturn. The sufferer therefore is the poor cultivator. The magnitude of this evil can be judged from the fact that whereas the area of water logged lands was only 4,000 acres in 1907, it rose to over 10,000 acres in 1924.

This is a serious evil, an evil which shows that the best attention of the Irrigation Authorities is needed for rectifying it.

2. Secondly, attempts must be made to start sugar factories on a wide scale and in a systematic manner. Such factories will enable the cane cultivator to get better prices for his product. When the price of gul and sugar is almost the same people as a rule are inclined to prefer sugar and the gul is neglected. Hence arises the importance of converting sugar cane into sugar.

The experiments conducted till this date have not succeeded well. The factories in the Deccan may be counted on the fingers of one's hand. We had the Malegaon Sugar Factory which failed some time back. We have also had the small factory at Fursangi which had to face great difficulties. The factory at Belapur is pulling on at present due to the Swadeshi sentiment. These few factories are really pulling on a precarious existence but no one can tell whether they will last for ever. Though the experiments tried in the Deccan have not succeeded well, we can succeed if Government

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1. See page 808 of Vol. XIV, Part V of the "Agricultural Journal of India".

were to help. But without such aid it becomes very difficult to pull on for a long time.

Government can encourage such factories, allow them to utilise the waste bye-products to the most profitable extent, and stop foreign competition by putting further restriction on the import from Java and other places abroad.

3. Lastly, sugar cane cultivation should be put on a more systematic and economic basis. There are many who consider sugar cane cultivation to be unprofitable to-day. It is no doubt true that our cultivators cannot easily give up sugar cane cultivation to which they have been accustomed for years past. There is also the difficulty of possessing the actual knowledge required for replacing the sugar cane crop by other crops. Besides the present irrigation cess might also prevent cultivators from bringing about such a change. It must be remembered that a great many of our cultivators are working on unsystematic lines. They plant cane very late, even as late as March and April. They are not very careful in watering and manuring and their crushing operations are crude. Their "gul" is often bad in taste and colour as a result of this and fetches very low value in the market. It would be well therefore if the Provincial Bank and the societies do something to make sugar cane cultivation more systematic. The Bank must finance but it must at the same time try to see whether or not cultivation is based on sound and scientific lines. This suggestion may appear crude specially as a proposed duty of a co-operative institution, but unless we try to attempt this and unless we do something to induce the cultivators to change their present unremunerative methods of cultivation, our members of societies will find cane cultivation a very unremunerative business.

The Group Secretary System and Methods of Finance.—As all co-operators know the secretaries of societies come to have special importance due to the inability of the Managing Committees to manage the affairs of the societies in the way they ought to. There are also what are known as the Group Secretaries. We shall note details about this Group Secretary System here because it is in the canals that it has been most developed.

There is in the Baramati tract what is known as the Joint Expenditure Scheme of Group Secretaries. According to this scheme there is one secretary for every two or three societies and the pay of the secretary is obtained from each society according to the strength of its working capital.

These secretaries are under the control of the Bhimthadi Taluka Supervising Union. They are mostly well trained men who are paid handsomely. Their task is a heavy one and hence they have to be paid something which can be sufficient to attract the right type of men. They are controlled not so much by the societies in which they serve as by the Union working under the orders of the Assistant Registrar. There are two or three societies which have neither joined the Union nor accepted the Joint Expenditure Scheme. The Union is the sole master of these secretaries. It recommends to the Registrar which secretary should be transferred to which society. The only defect is that the secretary is entirely independent of the influence of the Managing Committees of the societies he serves. These canal societies, it seems, can neither appoint nor dismiss their secretaries. Sole control rests with the Registrar.

Recently the Supervisor of the Union has taken further steps to strengthen his supervision over these secretaries. He has asked them to submit weekly statements about the working of the societies in their charge. These statements deal with such matters as the general progress of various individual members, the execution work of the awards passed against them, etc.

I have also heard that a new scheme has been forwarded for sanction in which new proposals have been made in order to remove the present want of co-ordination and other difficulties coming into the way of the economic management of the tract and also with a view to effect a better turnover of the work for purposes of putting comparatively much lesser strain and burden on the Joint Expenditure Scheme.

The last feature of the Canal Societies *viz.*, the peculiarities in the method and scope of finance needs elucidation.

In the very early days societies were organised to suit more the transfer of takavi loans rather than to suit the setting up of a true co-operative system of credit. There was no sense of joint credit. The system was mainly centred round the Special Mamlatdar. In the first place the landed assets of the members were valued after verifying the title through the Record of Rights. The Registrar was required to sanction every loan and he allowed finance upto one third the value of unencumbered estates of the applicant. Generally a cash credit was opened upto this limit. Applications for withdrawals on these cash credits were forwarded by the Managing Committees of the Societies through the Special Mamlatdar who had to supervise over the whole scheme and prevent reckless borrowing. In actual practice it was the Mamlatdar who came to exercise a veiled control over even the internal management of the societies. Each and every application

had to pass through him and had to be approved by him. He was at that time the only agency on which reliance could be placed by the Registrar and the Bank. He had for all practical purposes a power of veto. He also used to control the secretaries of the societies which in those days were grouped into five circles. His position was somewhat similar to that of the English Inspector under the Egyptian Agricultural Bank scheme. He was not only an adviser but also a supervisor to the financing agency. He used to work in the interests both of the lender and the borrower. The loan was made finally available to the member only after the sanction of the Registrar was obtained. In those days such drawing was made repayable within 24 months. The loans were advanced by the Bank at $7\frac{1}{2}$ per cent. and the societies passed them on at $9\frac{3}{8}$ p.c. They were recovered out of the sale of members' jaggery sold at the shop. All the members were bound to bring their produce for sale through this shop.

This system worked fairly satisfactory in the early days because the members of the societies, having been accustomed to the old system of Government takavi were taking the money from their societies as "Sarkari" money and were usually prompt in repaying them. Besides the higher standard of living was absent at that time. In addition to this advantage people had not learnt the business tricks they are employing to-day.

Gradually however the system broke down and arrears began to increase. It was felt that this method was not quite suitable specially because there was no arrangement for supervision by the financing agency. The Special Mamlatdar alone could not be expected to carry out the increasing work quite as efficiently as he was doing it formerly. Hence the Guaranteeing Unions came upon the scene.

Three such Unions were registered at Baramati, Malegaon and Pandhare with the function of supervising the working of the affiliated societies and recommending finance on their guarantee. In order to check the proper use of the loans given, advances from the societies for manure, and for top dressing of the cane were allowed only in kind thus ensuring that at least 45 per cent. of the total loans advanced were being used for the purpose mentioned. "Field Registers" and "Gurhal Diaries" were also introduced from which it could be known to what use the money was put to and as to what could be the expected recovery.

Though the system was as perfect as could be made in those days when our co-operators had not gained much experience of the canal tracts, it was really very defective in working. The committees of the Unions failed to respond willingly to the task before them. For

some time lump credits had been allowed by the bank to these Unions which were asked to distribute such credit amongst their constituents. This was soon given up due to rising arrears, in favour of the system of giving such credits to individual societies. This too however failed and the last stage was reached whereby the method of giving loans to individual members was introduced.

This old method of financing was found to have led to over-financing. I have already explained this as a cause of overdues. The Bank used to finance the members on the following scale:—

Old method of Planting	... ...	Rs. 400/-
Manjri Method	... ...	„ 350/-
Rattoon Cane	... ...	„ 250/-

It also laid down the rule (in 1919-1920) that it would not finance the cultivator for the purpose of preparing the ground and buying seed. This change in the method of finance it was forced to introduce in order to prevent penniless cultivators from growing sugar cane on disastrous lines due to inexperience. But even these remedies were inadequate.

The artificial improvement effected in 1921 due to a rise in the price of gul hid the true defects of the system to some extent. The post of the Mamlatdar was abolished consequently in 1923, and the Bank was allowed from this time onwards to make its own arrangements for finance and supervision. Having found that the Guaranteeing Unions were not of much use the new system of Supervising Unions was introduced. A new Supervising Union was set up. Another feature introduced about this time was the transfer of the purchase and sale business of the then existing shops under the Bank's management to a separate Sale Union which was registered in 1926.

But both these changes could not remedy the great evil of overdues. The Supervising Union failed in working. Even the Sale Union was not welcome to the then Senior Inspector who had submitted a long note to the bank warning it against this change. The evil of over-financing remained in spite of such remedies or changes introduced time after time.

Matters came to a head in 1926-1927. The figures for overdues given by me in a previous portion of this article will show this. The almost unbelievable rise in overdues within 1923-26 opened the eyes of the Registrar, Mr. Collins. But the remedy proposed and the change effected in the method of finance by Mr. Collins was worse than the disease. The Bank had been till this time financing to the extent of Rs. 500/- per acre but this was cut down by Mr. Collins to Rs. 450/- per acre and to almost nothing in case of those who were in

arrears. Payments for irrigation dues of the members specially were prohibited by the Registrar. This abrupt change was a serious mistake. The people became upset, there was wholesale demoralisation and a very large number of members sold their produce outside the Sale Union. This policy of withholding all finance was responsible for almost a complete loosening of the control over the cultivators.

The policy initiated by Mr. Collins was found to be impracticable because the overdues were not wholly and solely due to the dishonesty of the members. His remedy had failed to take into account the truth of the economic causes underlying the phenomenon of overdues. A special conference of field workers and representatives of the Bank, the Co-operative Department and of the societies and the Agricultural Department, was soon held to consider the serious position. It was decided in this conference to discourage cane cultivation, and allow long term extensions to facilitate repayments. It was realised that if no new loans were to be given there could be no hope of cultivation through the Bank's money and hence no hope of recovery of any of the old loans which were overdue. An arrangement hence was made according to which new loans were to be given to the cultivator on the understanding that he was to return the whole of it the next year along with a part of the old overdue amount. In this way it was arranged that the old overdues should be paid back in ten years' instalments.

The system of finance to-day may be briefly stated. Every member of the society has first of all to apply to the Managing Committee of his society. The Committee considers the application and makes recommendations to the Inspector of the Branch who makes inquiries and submits the application through the Senior Inspector to the Assistant Registrar and the Registrar. The Registrar has to sanction it and send the papers to the head office of the Bank. The head office communicates the sanction to the Branch and the Branch communicates it to the society. The society then takes the mortgage bonds of the members and the loan is transferred to the current account of the society. The member is then financed through cheques which are drawn on this current account in his favour. He comes to the Branch and finally gets the amount that has been sanctioned by encashing the cheque.

In case of manures and oil cake loans, the necessary sanction is communicated to the Sale Union, which advances the same in kind, and informs both the Bank and the Society about it, whereupon accounts are adjusted by both of them.

Most of the loans given are for sugar cane cultivation because sugar cane is one of the most important of the crops grown in this

area. The following figures will show very clearly the extent of finance given to the various societies affiliated to the Baramati and Nira Branches.

Statistics showing the amount of finance given for cane cultivation[1] to the Societies affiliated to the Baramati Branch (since 1920) and to the Nira Branch Societies (since 1926):—

Year.	No. of societies financed.	Outstandings on 31st March.	Recoveries during the year.	Fresh advances during the year.
1920	31	3,37,629	1,82,130	1,92,025
1921	31	4,60,876	4,32,913	5,56,159
1922	31	5,68,362	5,43,109	6,50,595
1923	31	7,76,183	5,42,550	7,50,371
1924	30	6,47,546	9,68,079	8,39,442
1925	31	10,47,471	5,42,483	9,42,407
1926	32	15,64,770	8,19,320	13,36,619
Nira	7	4,30,037	3,41,792	3,57,265
1927	36	14,28,443	10,26,780	8,90,453
Nira	7	4,95,511	2,05,953	1,42,366
1928	34	10,30,117	5,39,212	5,012
Nira	7	4,60,403	1,18,499	37,522
1929	31	9,30,595	Not known	22,508
Nira	7	4,17,906	88,932	4,979
1930	29	8,63,575	1,90,198	1,23,178
Nira	7	3,49,000	1,07,192	25,603
1931	30	8,68,879	1,68,074	1,73,372
Nira	6	3,39,818	45,490	40,826

1. By finance for "Cane cultivation" I mean finance for buying manures and oil-cakes and for paying irrigation dues.

These figures are sufficient to show to what extent finance for cane cultivation is made available since the last eleven years. Now we shall note something about the policy.

I find that in the Canal Societies, finance cannot be obtained by the cultivator to-day for all purposes. The idea kept steadfastly in view is to induce cultivators to spend something of their own for cane cultivation upto the stage of dressing oil-cakes.[1] The Bank is willing to provide finance only on the revised scale of Rs. 300/- per acre roughly as follows :—

Rs. 70/- per acre for payment of irrigation dues.

Rs. 150/- per acre for oil-cakes (this includes carting expenses and a bag of sulphate of ammonia).

Rs. 100/- per acre for "Gurali" expenses, i. e. for crushing cane, producing gul, etc.

It will be seen that the finance given is only for certain definite purposes as shown above and that too within the limit of about Rs. 300/- per acre. It was only in two or three cases where there were no previous dues and where the cultivator was exceptionally good that finance was given for all purposes. But this is really so very rare that we may leave it out of account entirely. It is not necessary to point out that there is no hope for tenants to be financed under such a scheme. There is a possibility of finance being given on personal security for very small loans but since there is no mutual trust this even is not practicable on any large scale to-day. As a matter of fact such "surety" loans have been almost neglected from the very beginning and all loans have been given strictly on mortgages. The surety system was found defective inasmuch as the sureties were found to dispose off land before anything could be recovered from them.

The other special features may be noted. In pursuance of the suggestion made by the Registrar in his note of 1928 special arrangements for recovery in this tract have been made by the appointment of "Recovery Clerks" and peons. There are about four Recovery Clerks for different groups of societies. They have to see that the loan is properly applied and used exactly for the purpose for which it is sanctioned. They have also to send reports at short intervals to the Senior Inspector of the Division.

The chief function of these Recovery Clerks is to carry out field inspection. They have to see whether the crop is at all planted or not and if planted whether it is done in time. They have also to press for the recovery of loans taken, so that overdues may be gradually diminished.

1. This amount is in most cases either borrowed from the Sowkar or obtained from the savings accumulated.

It is a question which deserves careful attention as to whether these Recovery Clerks are as useful as they are supposed to be. They are stationed at the following centres :—

1. Sansâr (for 7 societies there)
2. Baramati (for 7 societies around the town)
3. Pandhare (for 7 societies)
4. Korala (for 7 societies).

There are only three societies affiliated to the Baramati Branch where no Recovery Clerks where needed on 31-3-31. Such special measures as these however have been responsible for a gradual increase in the expenditure of the Branch and a gradual decrease in the profits earned every year.

Year	Expenditure	Profits
	Rs.	Rs.
1927–1928		21,130/–
1928–1929	3,489/–	13,754/–
1929–1930	6,717/–	9,253/–
1930–1931	7,983/–	4,458/–

Another feature is the power given to the Senior Inspector to sanction loans in anticipation of the sanction of the Registrar in a few needy cases upto Rs. 2000/– per society so that unnecessary delay would be prevented. The statements of loans sanctioned in this way are sent to the Registrar and placed before the Board of the Bank every month for approval.

Such special power of sanctioning loans prevents delay in important cases. In order to prevent inadequacy as well, powers for sanctioning special limits in case of good but needy cultivators is also given to the Senior Inspector. This is one of the redeeming features of the system. Big cultivators needing bigger loans would not find it possible to be financed to any reasonable extent by Co-operation if special limits were not sanctionable. Hence the need and importance of this special feature.

The following table will give a clear idea as to the extent to which such special limits have been sanctioned in some important cases.

Special limits for finance, sanctioned by the Senior Inspector of Baramati Branch for societies on the dates mentioned.

Name of Society	Date	Name of Member	Special limit recommended	Remarks.
Nimbut	5-12-31	Mr. S. B.	Rs. 15,073	1st period finance.
			" 12,100	2nd period
Nirawagaj	2-2-32	Mr. A. N.	" 3,529	1st period
			3,269	2nd period
		" N.V.G.	" 2,785	1st period
			3,185	2nd period
		" A.B.	" 14,809	1st period
			11,525	2nd period
		" M. S.	" 4,044	1st period
			3,929	2nd period
Dorlyachiwadi	2-2-32	" S.K.K.	" 3,086 (total)	
Zargadwadi	3-1-32	" G.B.	" 2,840	1st period
			3,590	2nd period
		" T.K.	" 6,533	1st period
			7,428	2nd period
		" V.D.	" 1,774	1st period
			2,014	2nd period
		" N.B.	" 600	2nd period
Kamleshwar	14-2-32	" V.P.K.	" 5,351	1st period
			5,451	2nd period
Korhale Bud-ruk	2-2-32	" V.S.P.	" 7,800	No period given
Tavashi	8-2-32	" K.G.S.	" 1,174	1st period
			1,600	2nd period
		" T.M.P.	" 2,417	1st period
			2,250	2nd period

These are some of the typical instances. They show clearly that if there is a good member he can get adequate finance once he is able to establish confidence. In case of these special limits the sanction of the headquarters is necessary but is usually expected in most cases.

This then is the position in the canal areas. We have taken a fairly comprehensive survey of the special problems. But it is also necessary to see what is in store for us in the future.

He would be a bold prophet indeed who would attempt to predict with any degree of definiteness and accuracy the future of the problem of the canal societies. It may however be conjectured that the Provincial Bank may have to suffer financially in these areas if the situation does not improve soon. But there is no need to despair. Signs are not wanting to show that with a little tactful handling of the problem many of the difficulties can be solved. The market for gul too is becoming hopeful again and prices may show a tendency to rise in the future. Slowly, by degrees, recoveries are also being made of the past overdues. But though this is true of the Baramati tract it is not exactly true of the Godavari and the Pravara canal tracts. It is there that the attention must be seriously directed and attempts made to try to recover the old overdues. Besides supervision must also be strengthened in all the tracts. On the whole however the problems of the canal tracts offer no immediate hope of solution though they are not such as to make us lose all hopes whatsoever of an improvement.

The remedies suggested for improving the position of our cultivators in the canals may be adopted. But no remedy will succeed and no improvement can be effected unless and until there is close co-operation between the Irrigation Department and the Co-operative Department. Government too must realise their responsibilities in the matter. The problem is so vast that its solution is well nigh impossible unless all the Departments and all the other persons concerned with the problem try to make genuine efforts in the direction and in so doing, co-operate with each other. Would it be too much to expect this co-ordination and co-operation for the common object of improving the situation in these canal tracts ?

PESY N. DRIVER

ETHNIC AFFINITIES OF THE CHITPAVANS (II)*

I

Many scholars have given their opinions about the origin of the Chitpavan Brahmins. The problem is a very old one but as yet no satisfactory solution has been put forward. The opinions expressed are different attempts to explain the name Chitpavan or to explain the myth of Paraśurāma given in the Sahyādrikhaṇḍa of the Skanda-purāṇa.

The first attempt of this kind was made by the late R. S. Mandlik.[1] According to him, the ancestors of the Chitpavans must have come from the sea in a ship. They might have started either from some other port on the Indian sea-board or from the other side of the Arabian Sea, possibly from the eastern sea-board of South Africa. They were then assimilated into the Dravida Brahmins. That part of the Konkan in which they stayed has been called Barbara-Konkan and to the west of Barbara-Konkan, beyond the sea, in the land of Egypt there is an ancient town named Berber fifty miles inward from the sea-coast. The country round this ancient city is called Berbery. Mandlik quotes a stanza from the Sahyādrikhaṇḍa where Barbara is mentioned as a part of the western sea-board:

केरलाश्च तुलिङ्गाश्च तथा गोराष्ट्र (सोराष्ट्र) वासिनः
कौंकणाश्च कुडालाश्च वरालाटाश्च बर्बराः ॥

—सह्याद्रिखंड, उ. अ. ६.

The people of Berbery, or Berbers as they are called, are tall, fair complexioned folk.[2] Mandlik derives the word Chitpavan from Jiptavan (जिप्तवान), which again is taken as a corrupt form of Egpyt-wan or Egyptwala, meaning one who has come from Egypt.

Obviously this opinion is based on the myth which makes mention sometimes of a wrecked ship. It is a very ingenious guess, for the Berbers are very much like the Chitpavans. Their photographs and profiles given by Ripley are very similar to those of the Konkanastha Brahmins.[3] The Berbers are called a proto-nordic element.

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(1) Mr. Gunjikar mentions Berbers as having cat's eyes and straight noses.

(2) गुंजीकर, सरस्वतीमंडळ, पृ. १४७–१५०.

(3) Ripley, *The Races of Europe*, pp. 44–45.

Again, this opinion is corroborated by another author, viz. of Sir R. G. Bhandarkar, who thought that the Chitpavans are to be related to the nordic race.

Enthoven notes that upto 1715 the word Konkanastha was not used.[1] It came into use after the first Peshwa. But even after him the Konkanasthas were employed in very degrading services, such as Harakaru or spies, and for many days the Deshasthas would not dine with them. In this connection Mr. Gunjikar relates a story of the 1st and 2nd Peshwa.[2] The Chitpavans were then illiterate and chiefly employed as cooks. Bajirao I was grieved to see the humiliating position of his fellow countrymen and brought two hundred boys from Konkan and taught them how to read and keep accounts. Thenceforward the Konkanasthas were employed in Government service as clerks and accountants in place of the Prabhus, who upto that time had monopolised those departments.

Jackson mentions that the Chitpavans were declared fit to dine with the Deshasthas by the Moraya Swami of Chinchwad, the Guru of the Peshwa Bajirao I.

The late Mr. V. K. Rajwade has done some work on this subject. It is scattered in different papers written for the Bhārata Itihāsa Sanshodhaka Mandala. In his paper about the origin of the Chitpavans: चित्पावनांची मूळपीठिका in the भा. इ. सं. मं. द्वितीयसंमेलनवृत्त published in 1914 he has given an account at some length tracing the economic and social conditions of this community from 1,200 A. D. to date. He bases his theory on the Paraśurāma Shaka (Era) extant in Malabar. He writes, that from Mangalore to Cape Comorin people use the Paraśurāma era, the first year of which coincided with the year 1927 of the Kaliyuga. So in A. D. 1914, (the year in which the author has published the paper), which is the year 5,015 of the Kaliyuga, the Paraśurāma era must be 3,088. Thus the era began 1,252 years before that of Śālivāhana. Rajwade then draws the conclusion that in 1,174 B. C. (the year 1 of the Paraśurāma era), fourteen men with Paraśurāma as their leader, first colonised the Konkan.

The Konkan is also called the country of the Nagas or Pātāla, the nether world. In this connection Rajwade mentions the names of the Bhandaris in the Konkan and shows that they end with the suffix Nak, e. g. Ramnak, Maynak etc. Nak is a corrupt form of Nāga, and hence these people, as also the Mahars who have the same terminations to their names, and also the kings of the Nāgas mentioned in the Mahābhārata are all people belonging to the Nāga tribes. The Bhandaris were sailors, the Mahars were Shudras and the Nāga kings

(1) Enthoven, *Tribes and Castes of Bombay.*

(2) गुंजीकर, सरस्वतीमंडळ, पृ. ११२–११३.

were Kshatriyas. He thus concludes that the modern Konkan was the country of the Nāgas, also called Pātāla or the nether regions.

Referring to Paraśurāma and his 14 men, whom he had brought with him, Rajwade says that generally the compound Paraśurāma is solved as Rāma with the Paraśu or battle-axe. But in Pāṇini Paraśus are cited as a warrior people and in the history of the Asuras too there is a mention of a people named Parsus. These seem to be the ancestors of the Persians or rather of the modern Parsis, and Paraśurāma means Rāma belonging to the country of the Parsus. Again, the patronym of Paraśurāma, *i. e.*, Bhārgavarāma, shows him to be a descendant of the Bhṛgus. These Bhṛgus were "Phrygians or Brigaus" connected with the ancient Thracians. Thus there is a connection between the Phrygians and Persians and to these two connected tribes Paraśurāma belonged. Paraśurāma with fourteen tired Brahmins had come in a ship from the West and first landed at Dabhul. They then went to Chiplun, where their first colony was established round the modern Paraśurāma or Mahendra hill. These Brahmins were worshippers of fire who always require five kinds of Chitis (चिती). Chiti is nothing else but three yards of ploughed ground on which there are designs in bricks resembling different birds. The fire kindled on this place is called Chityāgni or simply Chitya. The Brahmins were blessed and sinless (पावन) because they worshipped this Chitya and hence they were called Chityapāvana by the aboriginal Nāgas. This name later degenerated into the modern Chitpavan.

Speaking about this name, Rajwade also gives another derivation.[1] It is based on an old document found at Alibag in which the following signature occurs :

संमतोयमर्थः सदाशिवभ (ट्ट) दीक्षित
चितळे चित्तपावनस्थ धर्माधिकारी.

The document is written by a rather careless person and many letters are dropped *e. g.* the letter 'tta' (ट्ट) in the first line. Rajwade conjectures from the termination 'stha' (स्थ) in the word Chittapavanastha (चित्तपावनस्थ) that Chitpavana is the name of a country extending from Dapoli to Sashti. In this same connection he has derived the name from Kshitipavana (क्षितिपावन) meaning one who purifies people on earth.

He says that the name Chitpavan did not come into use from the name of the town of Chiplun, their first colony. This town is situated on the banks of the Vasishthi and of the Shiva. The former rises from the Sahyadri range while the latter springs from the range of hills near Chiplun. Thus Shiva is the river to which the town of Chiplun properly belongs and derives its name from Shivapulin (शिवपुलीन)

(1) राजवाडे, भा. इ. सं. मं., अहवाल, शके (१८३३) स. १९११, पृ. १२४,

meaning the sandy banks of the river Shiva. Rajwade also states that the caste system was prevalent in the country of the Parsus *i. e.*, in Asia Minor and Persia. Now it is necessary for those who worship fire to be Gṛhasthas *i. e.*, married. Paraśurāma therefore brought fourteen women from Amba Jogai in Hyderabad Deccan and married them to his fourteen followers. These women had brought with them their own goddess, the Devi Jogai, and henceforward the Chitpavans worshipped two gods, Paraśurāma and Jogai and still continue to do so.

According to Rajwade the colonisation of the Konkan by Paraśurāma and his followers took place after the battle of the Mahābhārata had been fought. Paraśurāma lived at a time when the great grammarian Pāṇini had died, the Daṇḍakāraṇya was being colonised by the Aryans and in the country of the Parsus the tyrants Asuras were ruling.

The foregoing account contains many assumptions and many points which we will have to discuss later. After this account of the colonisation and origin of the Chitpavans, Mr. Rajwade traces the economic condition of the Chitpavans as also the growth of population among them. He distinguishes five different periods of gradual rise in the population of this community. The first stage was the time when there were only the fourteen Gotras among the Chitpavan Brahmins. The second stage is the change of these fourteen Gotras into sixty surnames. In the third stage these sixty surnames increased to 130, in the fourth they became 250 and finally, at the present time, we have 350 surnames in the Konkanasthas. In the first two stages we find only the Gotras or surnames derived from the names of the Ṛshis who were probably the preceptors of the families. From the third stage people began to assume surnames derived from the names of the villages they lived in, or from the occupations which they followed. Thus 'Patankar' or 'Kelkar' are surnames of the first kind and 'Vaidya' and 'Deshmukh' are examples of the second kind. The document from which Rajwade derives the probable period of the fourth stage, is an old list of Gotras and surnames which he assigns to about 1200 A. D. The evidence put forward for this assumption is that names like 'Joshi' and 'Vartak' occur in that list but not those like 'Deshmukh' and 'Kulkarni'. Now it is known that about 1200 the Chitpavans began to take up the occupation of Vartak and Joshi after having given up their seclusion and the purely religious life of the worship of fire. About the same time the Shilāhār kings began to decline in power and so also the Karhadas, and the Chitpavans entered a new phase of their history in which they took great interest in the affairs of the world. In 1500 A. D. we already find many families of long standing as Kulkarnis and Deshmukhs and Rajwade justly remarks that their

entry into the politics of Hindustan was not an occurrence as sudden as the appearance of a comet. They had taken the first step towards it in 1200 and had been gradually preparing themselves in the affairs of business and the state. After the death of Shivaji the best politicians and warriors from the Marathas and the Deshasthas were killed in such large numbers that no more were forthcoming from these exhausted communities at least for a time and the gap was readily filled by the Chitpavans, who had slowly trained themselves for these high duties.

Rajwade also makes a very suggestive remark about the growth of the population of the Chitpavans. The table given below is reproduced from his article on 'Thenge Mata' in the annual report of the Bharat Itihasa Sanshodhan Mandal. In the first column are given the fourteen Gotras, in the second the sixty surnames belonging to each Gotra, in the third the number of the surnames belonging to the original Gotras at the time of the document referred to above, and in the fourth the total number of surnames belonging to each Gotra.

Kāśyapa	5	20	25
Śāṇdilya	8	35	43
Vasishtha	11	19	30
Kauṇḍiṇya	2	1	3
Vishṇuvardhana	4	3	7
Bhāradwāja	6	9	15
Nityundana	2	3	5
Gārgya	5	14	19
Kapi	4	9	13
Jāmadagnya	2	1	3
Vatsa	1	4	5
Bābhravya	2	0	2
Kauśika	5	18	23
Atri	3	7	10
Total: 14 ..	60	143	203

We see clearly that at the time of the introduction of the 60 surnames, each Gotra had not the same number of them attached to it. Similarly, the original surnames do not split into the same number of new surnames. The first three Gotras in the above list and Kauśika show the greatest number of surnames under them. Rajwade then asks the very pertinent question whether the actual number of people having these Gotras is larger than the others. If this is the case then we will have to conclude that some of the original 14 families have shown greater adaptability and virility than others. Some of them, *e. g.* Bābhravya, Vatsa, Kauṇḍiṇya, show almost no increase in the

surnames under them. It would be quite an interesting point to follow up and to see whether the number of people having these Gotras is actually smaller.

In yet another article[1] Rajwade tries to show that many of the surnames of the Chitpavans are in reality the names of ancient Ṛshis prevalent as Gotras before Baudhāyana. He concludes from this that the Chitpavans must have come into the Konkan long before Baudhāyana.

I have given a fairly full account of the work done by Mr. Rajwade, especially because he has worked on this problem more than anybody else and has applied his imagination and research in trying to solve it. How far the conclusion to which he has arrived can be accepted will be discussed in the next section.

In this same connection we have also to take into account the work of another scholar—Mr. Sane who wrote two articles[2] which contain answers to two of Mr. Rajwade's assumption. In his first article he refutes Rajwade's statement that Paraśurāma is the family-god of all the Konkanasthas. He gives a table containing the information which he had collected about 283 families from different parts of the Konkan (Parashurāma, Chiplun, Khed, Dabhol, Ratnagiri) and from Poona. In all these cases he found only three very doubtful cases where Paraśurāma was the family-god. Even in these three cases, the families came from Ratnagiri and Poona and not knowing definitely who their family deities were, had assumed Paraśurāma to be the family-god. Mr. Sane continues that Jogai is the deity of a very large number of families and the male deity is generally Velṇeshwar (वेळणेश्वर), Vāḍeshwar (वाडेश्वर), Kāḷeshwar (काळेश्वर), Laxmīnarasinha (लक्ष्मीनरसिंह), Keshavraj (केशवराज), Hareshwar (हरेश्वर), etc. He says that though the Chitpavans worship Jogai, the fact is not explained well by Mr. Rajwade's assumption that the wives of the first 14 ancestors came from Amba Jogai. It is only a statement in a myth and as such requires proof. Sane's second article is a comment on the guess or statement of Mr. Rajwade on the word Chitpavan based on the document found at Alibag. It is pointed out in it that the document, already confessed by Mr. Rajwade as carelessly written, does not contain some letters. Mr. Rajwade has already introduced a ट्ट after the भ in the signature;

संमतोयमर्थः सदाशिव भ (ट्ट) दीक्षित
चितळे चित्तपावनस्थ (ल) धर्माधिकारी.

and Mr. Sane wants to insert a ल after स्थ so that the signature would be that of an officer belonging to the place (स्थलधर्माधिकारी) itself.

(1) राजवाडे, भा. इ. सं. मं. प्रथमसंमेलनवृत्त पृ. १–२२.
(2) साने, " पंचम संमेलनवृत्त पृ. १४–१५.

In support of this, Mr. Sane states that the signature following the above is that of a provincial officer (प्रांताधिकारी). Moreover there is no mention either in myths or legends or old books about a country named Chitpavan. The Konkan stretched in olden times not from Dapoli to Sashti, as supposed by Mr. Rajwade, but from the river Savitri to Muchkundi, a much narrower country. According to Mr. Sane, the word Chitpavan is derived from Chitpolan (चितपोळण) an old name of Chiplun, which may either mean the sands on which corpses were burnt (चितीचें वाळवंट—स्मशान) or the land of learned people (चित्—बुद्धीचे—पुलीन). Sane thinks it probable that the Chitpavans originally came from Cutch or Kathiawar, as there are some points of similarity between the Cutchi language and the Konkani language as spoken by Chitpavans of Ratnagiri and Rajapur. They might have been called Chitpavans (of pure mind) by Paraśurāma, whom they helped in colonising the land. I have given this in full, as it refutes two very doubtful points in Mr. Rajwade's article.

Mr. D. R. Bhandarkar[1] contends in an article that the ruling houses of the western coast were foreigners. According to him the Shakas, the Huns, the Gurjars, etc., were all outsiders. They freely mingled with the people and many of them were admitted into the Brahmin community. He, therefore, concludes that all the communities on the western coast are more or less mixed up with foreign races and the Chitpavan community is also no exception to this, though he does not say with which particular race they have got mixed up. In another place[2] he says that they must have come from Palestine as many of their surnames bear resemblances to the names ol towns and provinces in that country.

II

It is proposed to devote this section to the interpretation of the material that has been collected. Following the precedent of other workers in this field, I will take up the Paraśurāma myth for consideration. It would, however, be better if the ground is cleared by first seeing how far and in what degree the hero Paraśurāma is connected with the rest of the western coast. If this issue is once made clear the further consideration will be made very much easier.

Gujerat, the northern part of the coastal strip is linked with the name Bhṛgu rather than that of Paraśurāma. A reference has already been made to the creation of the plane of the Bhinmal from out of the sea (Cf. J. Bom. Univ. 1932, *1*, 115). The modern name of Broach is derived from the ancient name of that city *viz.* Bhṛgukachha, which

(1) D. R. Bhandarkar, Indian Antiquary, Vol. XL, 1911, *Foreign Elements in the Hindu Population*, pp. 7-37.

(2) महादेवशास्त्री दिवेकर, ब्राह्मण मासिक पत्रिका, व. ५, अं. १-२, पृ. १८.

was famous at the time of Periplus in which the merchant calls it Barygoza and which is said to have been founded by the sage Bhṛgu. Even to-day this city and Surat are strongholds of the Bhārgava Brāhmins, who claim descent from Bhṛgu and who were once very powerful. A remnant of their ancient power and importance remains in the custom observed by all people including the Parsees, of giving a fixed sum to the Bhārgava community in every marriage.[1] Many Brahmins in this part of the country have traditions of having been imported from North India, especially Ahichhatra.[2] But in all these legends no reference is made even remotely to creation by Paraśurāma. The legend of land reclaimed from the sea seems to have originated in the land by conditions pointing to the existence of the sea-bed in the place where there is land to-day. It is thus a local myth and is not connected with the story about Chitpavans.

We shall next examine the traditions of the Havigs, Tulus and Namburis in the south. The country of Kerala is called Paraśurāma Kshetra and is said to have been created by the hero. We have already noted that the Brahmins in Kerala are also the creation of Paraśurāma according to a tradition current in Malabar. In this connection, Mr. Menon's remark about the Deccan being the source of the myth is interesting. On a closer study, Sahyādrikhaṇḍa is found to be the origin of all these southern versions. There is a tradition in Malabar that Paraśurāma created the land and peopled it with Brahmins but these early colonisers had to fly away before the onslaught of the Nāga warriors.[3] Some perished, others went away and Paraśurāma had to import Brahmins from Ahikshetra. He also created the Nayars to protect them and the Śudras to serve them. These Brahmins at first tried to rule without a king but only disorder ensued and at last they brought a king by name Perumal and installed him in their country. Each of the Perumals is said to have ruled for twelve years.

The Havigs claim to have been imported by King Mayurvarmā about the 4th century A. D. They too give an account of how Paraśurāma's Brahmins were cursed and how others had gone away and finally how they were brought into the country as there were no Brahmins there.[4] This account is given in the Gazetteer and all other authorities consulted by me also give similar accounts.

These accounts are taken from the Keralotpatti which is a work written in Malayalam. Kerala Mahātmyam also describes the creation of land and its colonisation. It is a book in Sanskṛt and the account is

(1) *Bombay Gazetteer*, Vol. 9, Part 1, pp. 1, 3, 8–9.
(2) Ibid., cf. Nagar Brahmins.
(3) *Gazetteer of Malabar and Ajengo Dist.*, Vol. 1, pp. 39–40.
(4) Ibid., p. 26.

supposed to be an excerpt from the Agnipurāṇa.[1] Keralotpatti belongs to the 17th century when many Purāṇas were translated into Malayalam.[2]

The name of the Havigs is connected with the Kadamba dynasty and the King Mayurvarmā. Lewis Rice, however, proves that they were brought into the country two or three generations before Mayurvarmā and established at Sthānakuṇḍur (Tālagundur).[3] The Kadamba dynasty ruled from the third to the sixth century A. D. and to this epoch belongs the immigration of the Havigs, the descendants of the Brahmins of Sthānakuṇḍur. It is said that they were compelled to leave unshorn a lock of hair on their forheads in order to prevent them from going back like the previous colonisers.

The Tulus tell a story about Brahmins who were originally fisherfolk. These Brahmins perished and the Tulus were brought from northern India to take their place.[4] A similar account of the Tulus is given by E. Thurston.[5]

Namburis were said to have been first living in Ahichhatra, from thence they migrated to the planes south of Kurukshetra and were brought to Kerala by Paraśurāma from that country.[6]

Among the Namburis there are certain sects which are not allowed to repeat the Vedas. Two of them are called Śāpagrastans or Śaptas and Pāpins (sinners). The former are the Brahmins degraded by the curse of Paraśurāma for their want of faith in him while the latter are those that purchased land from Paraśurāma and agreed to bear the sin of the slaughter of the Kshatriyas.

From all this we see that side by side with the myth about the creation of land and Brahmins by Paraśurāma, there is a tradition of Brahmins brought from northern India, Ahichhatra in particular, by King Mayurvarmā or by Paraśurāma himself. Namburis and Havigs refer to a previous colony of Brahmins who were originally fisherfolk and who had perished at the hands of the Nāgas. They themselves never refer to Paraśurāma as their creator. The two sects of Śāpagrastas and Pāpins support the tradition of these Brahmins. All the Malabar Brahmins appear to have taken the Paraśurāma myth from the Deccan and so the people do not consider themselves as the creation of Paraśurāma as the Chitpavans implicitly do. All these

(1) *Gazetteer of Malabar and Ajengo Dist.*, Vol. I, pp. 39-40.
(2) Ibid., pp. 92-93.
(3) Lewis Rice: *Mysore and Coorg from Inscriptions*, pp. 21, 26; *Gazetteer of Malabar*, pp. 44-45.
(4) L. K. Anantha Krishna Aiyar: *Cochin Tribes and Castes*, Vol. 2, pp. 344-345.
(5) E. Thurston: *Castes and Tribes of Sourthern India*, p. 385.
(6) L. K. Anantha Krishna Aiyer, loc. cit., pp. 170-171.

Malabar Brahmins point to some distant period at which they were definitely brought in with great respect by some king. The curse of Paraśurāma has fallen on the whole of the Chitpavan community, while only the two sects among the Namburis mentioned above are said to have suffered from it. It is possible that these two sects were excommunicated for some other reason, which has now been forgotten.

In Keralamahātmyam[1] is given an account of the creation of Malabar and the importation of Brahmins into it. After this follows a more or less consistent historical account of the attempts of the Brahmins at a peaceful settlement and their laws about agriculture and rituals. The account of the Perumal dynasty is given and it is noted that each king had to rule for twelve years only.[2] From this it seems that there was an historical tradition about Kerala kept intact by the Brahmin community. This tradition was connected later on with the name of Paraśurāma when the Sahyādrikhaṇḍa became known in the south. One can easily see that the name of Paraśurāma became a ready point of reference for all existing laws and traditions, the origin of which had long been forgotten.

We can thus eliminate the Bhārgava Brahmins in the north and the Namburis and the Havigs in the south from the list of Brahmins created by Paraśurāma. The country from Gujerat to Cape Comorin is still a Bhārgava country. Gujerat was inhabited by Bhārgava priests from times immemorial. Paraśurāma, a warrior of the same family extended this influence as far as southern Konkan, and the coast upto Cape Comorin did not escape the influence of this great name. This does not however mean that the Brahmins from all these parts belong to one single wave of Aryan migration into the western coastal regions, as would appear from a superficial reading of the myth. The Chitpavans alone have no other tradition in connection with their origin except this myth.

The Saraswats of Goa are connected with Paraśurāma, but according to their tradition, they were not created by him. There are different theories about their original home in northern India, but the traditional account as given in the Purāṇas makes them Brahmins staying on the banks of the Saraswati and disciples or sons of a Ṛshi named Sāraswat, the son of Dadhicha. They had spread from the banks of the Saraswati into the east and Paraśurāma brought them from Trihotra to assist him in his triumphal sacrifice. Tradition thus points to a definite region in northern India as the original home of the Sāraswats. They were invited by Paraśurāma *after* the latter had

(1) Nagam Ayya: *History of Travancore.*

(2) Frazer: *Golden Bough* (abridged edition), pp. 275-276.

settled in the new land and had not accompanied the hero nor have they been created by him.[1]

From what has been written in the foregoing paragraphs we can see that we can concentrate our attention on the Chitpavans only in discussions about the Paraśurāma myth and leave out all the others as connected with the hero only indirectly.

The myth has already been dealt with in all its aspects (cf. This Journal, 1932, *1*, 115) and the following working hypothesis is suggested by the story. Paraśurāma, with a few others plotted to kill the Haihaya Princes. From their home on the banks of the Ganges these heroes travelled all the way south to the banks of the Narmadā where the city of Māhishmati was situated. There the Haihaya Princes were killed, but the party had to fly away in haste and went to the lonely western coast either via. Nasik or by the sea-route via. Prabhāsa. In the perilous journey, whether by land or sea, all save a handful were killed. Paraśurāma brought women from the south and married them to his followers. It is these political refugees who have been the forefathers of the present day Chitpavans.

The story of Paraśurāma is an episode in a long series of events lasting for over a century. It began with King Arjuna of the Haihayas and ended with the defeat of a Vitihotra and the fall of the House. The beginning was marked by the rising of a new power on the banks of the Narmadā. In the middle of the period that power had reached its zenith and the end came soon afterwards with the sudden overthrow of these stubborn southerners. This new power was that of the Tribe of the Haihayas, which included within itself many other smaller tribes. King Śaryāti, a forefather of the Haihayas, ruled over Anarta, a portion of Gujerat. In his times the connection with the Bhṛgus was first made by the marriage of Sukanyā, the King's daughter with the old Bhārgava sage Chyavana. After this marriage Chyavana performed many sacrifices for the King and he and his family became family-priests to the house of Śaryāti. The tribe of this King dwindled and his kingdom was finally amalgamated into that of the Haihayas a kindred tribe. This change of power however brought about no change in the family-priests. The office remained in the hands of the Bhārgavas, who had grown rich by the generosity of their patrons. A feud about money matters arose between the royal house and the priests, with the result that many Bhārgavas were ruthlessly slaughtered, and the survivors fled away to the Himalayas (Cf. The account given in J. Univ. Bom. 1932, 1, 115). Driven from their ancient home, the family made a new home on the banks of the Ganges, nursing their wrongs and seeking alliances with the kings of

(1) गुंजीकर, सरस्वतीमंडळ, पृ. ५–११.

the North. We have seen that the friendship of the Bhṛgus and Viśvāmitra, the royal sage of the House of Kānyakubja, was due to the fact that the latter's sister Satyavati was given in marriage to the Bhṛgu sage Ṛchika and that Reṇukā, the mother of Paraśurāma was a princess of Ayodhyā.

In the meantime the Haihayas had waxed powerful. From their southern fastness on the banks of the Narmadā they had sent forth powerful armies into the north and were conquering the ancient kingdoms of the Madhyadeśa. It was at this period in the times of King Arjuna that the members of the Bhārgava family and the King came into a clash on the banks of the Ganges and Arjuna was killed. His sons were then slaughtered in his capital Mahiśmati. Upto this point the narrative is cogent enough. Then follow the events of the sacrifice, the creation of Śurparaka, the retirement to Mount Mahendra and the destruction of the Kshatriyas for twenty-one times. To this are to be added the episodes ascribed to Paraśurāma in the Mahābhārtata and the Rāmāyaṇa. The task before us is now to interpret all these events and give a consistent account of the life of Paraśurāma after his daring act in Mahiśmati.

Arjuna and his sons were succeeded by the Tālajanghas who were related to them, and formed one of the tribes included in the Haihaya group. They were very powerful and with the help of the hordes from the North-West swept the Madhyadeśa conquering the ancient kingdoms of Kāshi and Ayodhyā. Thus we see that the rising tide of Haihaya conquest was in no way stemmed by the murder of King Arjuna and his sons. If there was collapse and panic in the ranks of the Haihayas, it was but momentary. The armies soon rallied and led forward in their triumphant career by the capable Tālajanghas and no change occured as far as the political situation was concerned. On the other hand, Paraśurāma's condition was precarious. His act does not seem to have been the outcome of widespread political conspiracy against this southern power. It was a sudden impulsive action of an impetuous sensitive youth and it took unaware both the Haihayas and the northern Princes. The latter therefore could not take advantage of the opportunity, offered them by the sudden murder of Arjuna, to crush the kingdom in the south. Perhaps Rāma was helped by some youths of his own age, but there was no other powerful backing. The long delayed revenge was fully taken but after it Paraśurāma could not go back to his hermitage on the banks of the Ganges and live peacefully and unmolested. The House of Kānyakubjā with which he was connected could not support him. The generation of Jamadagni, Hariśchandra and Viśvāmitra had passed away at the time of Paraśurāma's exploit. The Kings that followed were not strong enough to protect their own domains, far less to give support to a rebel. The House of

Ayodhyā was presided over by a weak king and therefore no help was forthcoming from Paraśurāma's mother's kin. He had thus to secure a place of refuge in the north, where the Haihayas were all-powerful. But the country lying south of the Vindhyas was an unexplored forest where the arms of the Haihayas could not reach and thither Rāma wended his way, reaching at last the western coast.

It is said that some women were brought from Gokarṇa and married to these first colonisers. This is quite consistent with the facts discussed above. Paraśurāma and his followers could not naturally take their womenfolk with them on their perilous flight. They had perforce to leave their homes in great haste. It is quite possible that one or two women might have accompanied the group or survived the dangers of the travel; but there could not have been enough women for them all. Hence the new settlers had to marry women from amongst some southern community of a non-Aryan culture and possibly of a non-Aryan race. The original colony at Śurpāraka was shifted southwards to the ports of Chiplun and Dabhol and to this day the country surrounding these towns remains the stronghold of the Chitpavans. The Chitpavans of to-day thus seem to be a mixture of the northern Indo-Aryans and the southern Dravidians. It is not intended to convey by the two terms Aryan and Dravidian, which I have used here, that the two races were pure and unmixed. The name Chitpavan as explained by Rajwade in one of his articles (see above) seems to be the most plausible explanation, yet put forward. The Bhṛgus are noted as fire-priests and their services were indispensable for Agnisthāpanā of different kinds. One way of arranging the fire was the construction of a Chiti (चिति). A Chiti, as Rajwade explains, is a particular arrangement of Bricks on which a sacred fire is lighted. The Brahmins led by Paraśurāma, a Bhṛgu, possibly arranged their fire in this way. They were blessed by Chityāgni (चित्याग्नि) and hence got the name Chityapāvan corrupted later to the Chitpavan of the present. The story of the shipwreck and the curse constitute a knotty point in the myth. We have seen that there are, here and there, traditions of a handful of Brahmins cursed by the hero, but the Chitpavans alone of the Brahmin communities of the west coast, retain the title of a cursed people. The hypothesis put forth by Oppert, that all the traditions of curses and Brahmanisation mean that the aboriginal priesthood was first made Brahmin and then cursed giving it thus a social position of great importance only a little below the true blue-blooded Aryans, does not seem to apply to the Chitpavans, whatever its significance as regards the other Brahmins of the west coast. The Chitpavans have always been known as Vedic Brahmins, in spite of their being despised by the Deśasthas, their humble profession of farming and their former low and despised position as spies and cooks. They keep many Vedic

traditions and are also sharply distinguished from the Kunbis and Kolis, the aborigines of the Konkan. The curse coupled with the legend of the shipwreck may perhaps mean the infusion of some foreign blood. We have already noted Mandlik's theory in this connection. Gunjikar also takes note of a tradition which says that the Chitpavans were taken away by Yavanas from beyond the sea, that they lived with them for two or three years and that they finally came back to their native country.[1] This is also given as the reason of the Deśasthas despising them. However, the legend has been proved to have been of very recent origin and it is doubtful whether it is true.[2]

Rāma's deification was a very late event. In the main narrative of the Mahābhārata he is shown as a great warrior but not as a god. It is only in the later Parvas which are philosophical and ritualistic that he is described as an incarnation of Vishṇu. These Parvas and Harivamśa are later additions to the old text, some of the portions being compiled in the beginning of the Christian era, as the description of Buddhism, and accounts about many new countries and also of foreigners like Greeks etc. are incorporated in these.[3] Rāmāyaṇa, which has been composed later than the older portions of Mahābhārata, contains no hint of Rāma's godliness. On the other hand, in one of the passages he is compared with other heroes and dutiful sons and called a "peer of god," thus implicitly denying his divinity. It was at the beginning of the Christian era that Paraśurāma's name was included in the list of Avatāras and the honour of divinity bestowed on him.

His being a matricide is another point requiring attention. The incident has no bearing on the events that followed, but is recorded in all the versions of the story from the Mahābhārata onwards. It must have actually taken place and so simply recorded by all the chroniclers. It lends a greater fierceness to the already fierce character of the hero before whom everybody is said to have trembled. But the story of the revival of his mother, which follows immediately after his killing her, seems to be a later addition when the sense of the blood-guilt had become strong, especially as regards the killing of so near a relative as one's own mother. In order that so great a name as that of Paraśurāma should not be tarnished by this unnatural and bloody act, in order that the stern fact of matricide be modified, the story of the revival was added afterwards. It is curious that Paraśurāma, claimed as a deity, never escaped the blood guilt for butchering the Haihayas. When he killed Arjuna, his own father asked him to do penance for

(1) गुंजीकर, सरस्वती मंडळ पृ. १५०–१५४.

(2) Ibid., पृ. १४५–१४६.

(3) F. A. Pargiter: *Ancient Indian Historical Tradition*, p. 23; *Encyclopaedia of Religion and Ethics*, cf. article on Mahābhārata; Hopkins: *The Great Epic*.

killing the King, who, he said, was as good as one's own father. After he had killed the Kshatriyas, he begged his ancestors to show him how to atone for his sin and was told by them to bathe in certain sacred places in the rivers Ganges and Saraswati. The short period when he caught the imagination of all by his instant and merciless revenge and the momentary exaltation is followed by penances and purificatory rites. He was rash and impetuous by nature. The three acts of matricide, killing Arjuna and the extraordinary visit to Mahishmati, where he killed Arjuna's sons are all followed by moments of self-humiliation. Although his family was warlike from the first, he was born and bred as a brahmin and so his exploits are always thought of with wonder and fear as something out of the ordinary and unexpected. The profession of war and the killing of enemies, which came so naturally to Rāma Dāsarathi or to Kṛshṇa, both Kshatriya youths, could not have been so natural to this Brahmin hero. At the end of his career he becomes a pilgrim wandering through unknown regions of the south-west coast of India.

Another point of interest in the story is the erection of the golden altar and the gift of the earth to Kāśyapa. Considering the political situation and Rāma's position after he had put to death his enemies, it does not seem possible that he could have performed a big sacrifice in a triumphant way and bestowed the earth which he had never conquered, on Kāśyapa. The true character of the gift is hinted at in one of the passages in the Anuśāsana Parva, where Bhishma tells Dharma the virtues of gold. The gift of gold to Brahmins is supposed to atone for great sins and the case of Rāma Jāmadagneya is cited. Thus it seems that the sacrifice and the gift of gold were acts of atonement for the sin committed. These rituals must have been performed in haste as Rāma had to hurry away to a place of comparative safety. The Pṛthvi-Dāna must be a later version of those facts, taken from an old legend about an ancient King Viśvakarmā Bhauvana. In later times Paraśurāma was not considered as a fugitive at all but as a triumphant divinity vanquishing the forces of evil and the whole of the old tradition was so twisted as to serve this new conception. In this same connection is narrated the old myth that the earth came to Kāśyapa and asked that Kshatriya rulers may rule her and bring peace on the land. Rāma is supposed to have killed all the Kings, but many children of the royal houses were secretly brought up and these were established in various countries by Kāśyapa. A long list of these Kings is given in the Mahābhārata. This fabulous account is based on an historical fact. The Haihayas for more than a century held sway over the Madhyadeśa, driving away or killing the Princes of Ayodhyā and Kāshi and other ruling houses of the north. The two Princes named, finally freed the Madhyadeśa from the terror of the Haihayas

and established peace in the land. Both of them had been brought up in obscurity and Sagara, the Prince of Ayodhyā was sheltered and educated by the Bhṛgu priest Agni Aurva.[1]

A few facts still remain to be explained. Rāma Jāmadagneya was far anterior to Rāma Dāśarathi and the Pāṇḍavas, but he appears as a contemporary of both. This grave anachronism is worth looking into, if we want to determine the period at which Paraśurāma actually lived. The Rāmāyaṇa reference which tells about the encounter between the two heroes appears to be a deliberate anachronism. We have already discussed the purposes served by the passage. The original story of Rāma Dāśarathi has no hint of his being an incarnation. The Rāmāyaṇa has not been composed by one single poet and the declaration about the divinity of Rāmachandra is the work of some later poet inserted in the original narrative. The passages in which these declarations occur are all discrepant and have no connection with the narrative proper. This particular passage we are dealing with is highly absurd. The idea of one incarnation being defeated by another and afterwards humbly declaring the greatness of the rival is ludicrous. We must discard this reference as worthless after noting that it is symbolical of the reassertion of the Kshatriya prestige. The other reference is more natural. In this passage (J. Univ. Bomb. 1932, 1,129) Rāmachandra is citing examples of dutiful sons and couples the name of Paraśurāma with that of Sagara as great men of ancient times equal to gods in their goodness. Here Paraśurāma is represented as belonging to some earlier period. His name occurring with that of Sagara is also significant, for although the two were not contemporaries, they played an important part in a great historical event, the rise and fall of the Haihayas. The task begun by Paraśurāma was completed by Sagara. In calling these heroes "peers of god" they are really declared to be human. This reference thus contradicts no tradition. It is eminently reasonable and confirms all the points we have discussed above. The Mahābhārata references too are of two different kinds. We need not stop to consider here the traditionalised lists of Ṛshis where the names of the living and dead sages are all mixed up. The other references, viz., those about Karṇa, Droṇa and Bhīshma appear by their naturalness to be historical traditions. All these allusions together with that in the Rāmāyaṇa as also those found in the later Purāṇas invariably connect Paraśurāma with Mount Mahendra. Now Rāma would have had to travel all the way from Mahishmati to the banks of the Ganges and from there eastwards to the shores of the Eastern Ocean in order to reach this mountain. We have already seen how this northward retreat was barred to him and how he had to fly to the isolation of the western coast. Śurpāraka, the city of Rāma

(1) Pargiter, op. cit., p. 200.

and Mount Mahendra are separated by the breadth of a whole peninsula. The former is situated on the shores of the Indian Ocean while the other borders on the Bay of Bengal. That Rama should have visited the Eastern coast in his life-time seems impossible. How then can we explain this persistent connection of Rāma with Mount Mahendra found in the two epics and in all the Purāṇas? There seems to be but one possibility, viz., that there were more than one Paraśurāmas. Rāma himself was unmarried and no son of his is referred to in the traditional accounts, but we hear of brothers who were not as distinguished, but who might have married and had sons some of whom were called by the same name. We know that there were many Viśvāmitras, Kāśyapas and Vasishthas. In the same way there might have been more than one sage of the name Paraśurāma in the Bhṛgu family who kept up the warlike tradition of the original hero of that name, in being proficient in arms though never actually engaging in fighting. One of the later Paraśurāmas might have made a home on Mount Mahendra and have been revered like his name-sake. This would also explain the Mahābhārata references in which Paraśurāma is alluded to as being the teacher of various warriors and as living on Mount Mahendra. This name Mount Mahendra is given to-day to be the shrine of the hero near Chiplun. The old shrine was at Śurpāraka, where Dharma and his brothers stopped in their pilgrimage on their way to Prabhasa. The new shrine was built in historical times by Brahmendra Swami Dhāvadśīkar.[1] The old shrine was no longer known to to the public and this new shrine was more or less a revival of the memory of the half-forgotten father of the Chitpavans. The Puraṇic tradition of Mount Mahendra being the residence of Paraśurāma was well known and hence the hill on which the new temple was built was given this old name and became a sacred place dedicated to the hero. There was an old shrine on the hill but it had long been forgotten and was not frequented. Very probably it was a natural Linga, for below the images I was shown three natural Lingas of Siva. Brahmendra Swami built the temple as it stands to-day and became very famous in his days. It is thus clear that the Mount Mahendra in the Konkan is a recent name given to a hill and taken from the Purāṇic tradition about the home of a Paraśurāma later than the supposed creator of the Konkan. The confusion which the Purāṇas make between these two or more heroes is not at all uncommon. We find that the Vasishtha and Viśvāmitra of the Dāśarathi times are confused with the sages of the same name who lived in olden times and were contemporaries of Jamadagni. Curiously enough, the friendship between the Bhṛgus, especially Jamadagni and Rāma and Viśvāmitra is referred to in the Rāmāyaṇa passage as "ब्राह्मणोऽसीति पूज्यो मे विश्वामित्रकृतेनच" i. e. for

(1) पारसनीस, ब्रह्मेंद्रस्वामी धावडशीकर यांचें चरित्र, पृ. ५-७.

Viśvāmitra's sake beside, shall reverence due be ne'er denied (Griffith). We thus see possibility of there being more Rāmas than one in the Bhṛgu family, all confused together through carelessness and lack of historical tradition on the part of the chroniclers.

After having cleared up the various ambiguities and anachronisms in the legend of Paraśurāma, we come to the question of the period at which he lived. We have already noted Rajwade's effort to fix the date of the colonisation of the Konkan by referring to the Paraśurāma era in Malabar. The era, also called Quilon or Kollam Andu is current from Mangalore to Cape Comorin and in the Tinnevelly District. It is a cycle of a thousand years each. The present cycle is the fourth, though people generally include in it the thousand years of the last *i. e.* the third cycle and count the present year as 1094 instead of 94 of the 4th cycle. The era must have begun in 1176 B. C.[1]

This era is connected by some historians with Mayurvarmā and the importation of Brahmins into the Malabar. But Mayurvarmā has been shown to have been far anterior to 824, the date of the beginning of the third cycle and the one assigned to this king. Neither can the date be connected with Cheraman Perumal, the last of the Perumal Kings, who ruled in Malabar.[2]

V. Gopala Aiyer connects the commencement of the era with the end of the Mahābhārata battle and the commencement of the Kali-Yuga.[3] The era is, according to him, really the Kali-Yuga era brought to the south by the Namburis and kept intact like so many other ancient customs which they have preserved. His calculations seem to be very plausible. He works back from the date of Chandragupta to the date of Parikshit by calculating the average duration of the reigns of the kings of different dynasties given in the Purāṇas. Pargiter employs the same method and arrives at 950 B.C. as the date of the battle of Kurukshetra.[4] The difference between the two calculations is due to the number of years assumed to be the duration of the average reign by the two scholars. The date 1176 B. C. is supported by other astronomical evidence and historical facts quoted in full by Aiyer and we might take it as the basis of our calculation. Moreover Dixit arrives at approximately the same date by a different method.[5] This beginning of the Kali-Yuga was however forgotten when such great and influential astronomers like Varāha and Nihir pushed back the commencement of that Yuga to 3102 B.

(1) दीक्षित, भारतीय ज्योतिषशास्त्र, पृ. १७७, १७८, १८०.
V. Gopala Aiyer : *The Chronology of Ancient India*, pp. 42-56.
(2) V. G. Aiyer, loc. cit., pp. 42-56; Lewis Rice, op. cit., pp. 21-26.
(3) V. G. Aiyer, op. cit., 44-45; also last chapter.
(4) Pargiter, loc. cit., pp. 177, 179-183.
(5) दीक्षित, loc. cit. पृ. १२५.

C.[1] The Namburis had therefore to give some other name to their era and the name of Paraśurāma, the supposed creator of Malabar, came in handy.

It would thus become clear that the era has, in reality no connection with Paraśurāma and is really the Kali-Yuga era under another name. We cannot therefore take it as a guide towards determining the period of the colonisation of the west coast, and will have to follow the method used in the determination of the date of the Mahābhārata battle. Pargiter has given tables of genealogies of the different lines of kings from Manu, the first king, upto Abhimanyu's generation, which was the youngest generation to fight in the battle. Kārtavirya Arjuna is the 30th king from Manu while Abhimanyu's generation is the 95th. Rāma Jāmadagneya was a younger contemporary of Arjuna and belongs therefore to the 31st generation after Manu, which is also that of the sons of Arjuna. Thus 64 generations of kings ruled between the date of the murder of the Haihaya Princes and the great battle of Kurukshetra. Pargiter takes the average duration of the reign of a king to be 18 years and the 64 generations would therefore mean a period of 1152 years. Paraśurāma's period must therefore have been 1152 years before the battle of the Mahābhārata, to which Pargiter assigns the date 950 B.C. and we thus arrive at the date 2102 B. C. According to Aiyer, the average duration of the reign of a king is to be taken as 22 years, which seems to be rather high. Paraśurāma's period would, in this case, be 2584 B. C. ($22 \times 64 = 1408 + 1176 = 2584$). Taking all this into consideration, Paraśurāma's period would be somewhere between 2000 and 2500 B. C.

Rajwade's contention, that Rāma colonised the Konkan after the Mahābhārata battle is not borne out by evidence. The basis of his calculation, the Paraśurāma era, has, as we have seen, no connection with the hero. His surmise about the nationality of Rāma seems also to be incorrect. He lays stress on the words Bhṛgu and Paraśu which, according to him, are indicative of the names of two peoples the Phrygians and Persians and points to the fire-worship of the Bhṛgus as being of Persian origin. Fire-worship is common to both the branches of the Aryans, the Atharvan Priests and is also a common feature of the rituals of the ancient Indo-Aryans and Iranians. The Indian Aryans may have taken many of the forms and conceptions of the Persians, but that does not mean that they had to import priests from Persia. The Bhārgavas are a feature of Indian mythology from the earliest times and are mentioned in the Ṛgveda as a very learned and respected branch of Ṛshis. The name Paraśurāma too does not

(1) V. G. Aiyer, op. cit., pp. 62-66, 85.

point to the warlike Paraśu tribe mentioned in the Ṛgveda. Paraśurāma is a very recent appellation of Rāma and has been used after the Harivaṃśa Purāṇa had been compiled. This Purāṇa is supposed to be the latest composition of the Mahābhārata epic and is referred to the beginning of the Christian era. In the Mahābhārata and Rāmāyaṇa texts, Rāma is mentioned by his patronymic and it is only in the later Purāṇas that the peculiar weapon carried by him struck the fancy of the compilers and its name was attached to his name as a device to distinguish him from Dāśarathi Rāma. If it had any connection with the Paraśus, as Rajawade suggests, it would have been in use in the Mahābhārata text. It is quite a recent nomenclature and conveys no meaning beyond the emphasis laid on the peculiar weapon of the hero. Neither is that a very unusual procedure. Balarāma, Kṛshṇa's brother is known for his weapons and has been called Halāyudha (हलायुध) and Musalāyudha (मुसलायुध). However Paraśurāma seems to be the only case where the name of the weapon has been compounded with the name of the person. We do find combinations like Chakrapāṇi Halāyudha, but they are independent of the actual name. Taking all the points into consideration, Rajwade's conjecture seems to be far-fetched. If one has to reason on the same lines, all the Ṛshis of olden times would have to be imported from Persia just because Mitra and Varuṇa are deities common to both the branches of the Aryans.

So far we have seen reason to establish an intimate connection of the Chitpavans with Paraśurāma. The first colony with Paraśurāma as its leader seems to be of Aryans from Northern India. The attempts at finding out the racial affinities of this group by establishing Paraśurāma's connection with the Persians are seen to be baseless. The age of Paraśurāma seems to be somewhere about 2000 B. C. There also seems to be a great probability that this Aryan group mixed with some other people of the South which were of non-Aryan affinities. We have yet to decide the cultural and physical heritage of this foreign group as also of the Aryan pioneers and to this task we now turn our attention.

The most important point which strikes us in the examination of the data regarding the eye-colour is the extensive range of eyes from the darkest to the lightest shades that is found in this community (of Part I of this paper, this Journal Jan. 1933). At one end of the scale we have the black and the dark brown and at the other end we have grape-green and the cat's eye. Between these two are the the light brown and the green-brown eyes which have been classified as light eyes in the tables given in Part I. As a community, the people must be said to have brown eyes, while the green and the cat's eyes are two other distinct shades. A pure unmixed race

would not show such a variety of shades. The pure Nordic type, the pure Negro or Mongolian are all confined to particular shades, either light or dark. The Mediterranean races, the Spahish, Italians and Greeks have this kind of mixture of dark and light eyes among them. But they are not pure races and have been exposed to the influence of Moors, Semitics and Mongolians on the eastern side. Ripley remarks that a Greek in Asia Minor looks more Semitic than Aryan. There has also been a mixture of northern blonde races and all these together form the Mediterranean people of to-day from Spain to the Balkan States.[1]

The western coast of India was never a scene of such great mixture of people meeting for commerce, though it must have been subjected to Semitic influences in the period of its commercial prosperity for centuries, from 700 B. C. right upto the conquest of the country by the Mahommedan kings of Gujerat. The Dravidian element is never absent in any community living in the country south of the Vindhyas, and it is this element which seems to constitute the darker shades in the eye-colour. The fact of sex-linkage in the eye-colour[2] coupled with the fact that the women show on the whole darker eyes than men is a significant point and corroborates the tradition that women were brought from the south for the first colonisers. The lighter-eyed element seems to be the Aryans. No study of the eye-colour of the people of North India, who are supposed to be the best representatives of the ancient Aryans, has as yet been made. Indo-Afghans are reported to have invariably brown eyes. In a study of the people of Eastern Turkestan the bluish element in the eyes has been attributed to Iranian mixture.[3] As far as I know, no community in India is reported to show green or blue eyes, neither have I heard a people called definitely light-eyed as the Chitpavans are known to be in Mahārāshtra. The Sāraswats and the Karhadas have sometimes green or cat's eye shades, but they are not known particularly for this trait, as are the Chitpavans. The statistical tables and the curves in Part I show that the Chitpavans in the Deccan have on the whole darker eyes as compared with the members of the same community in the Konkan. In both cases however, the green and the cat's eye shades remain practically unchanged in their frequency. They seem to behave like recessive characters and appear in certain small but definite percentage throughout, irrespective of age or sex. In this connection a word of explanation is necessary. The cat's eye, as can be seen from the tables, appears in a somewhat greater percentage frequency in the case of the children

(1) Ripley: *Races of Europe*, pp. 268, 272-279, 409-410, 432-435.
(2) R. R. Gates, *Heredity and Eugenics*.
(3) T. A. Joyce, *J. R. A. I.*, 1912.

and old people. Side by side with this we have to take note of the brown eyes that acquire a gradually increasing bluish ring and becoming, in many cases, purely blue in extreme old age. The brown pigment in the eye is secreted on that side of the cornea which faces the world, while the non-pigmented or lightly pigmented side faces the brain. If the brown pigment is absent, we get an impression of a blue or grey eye, as is the case in childhood when all pigmentation, whether of skin, hair or eye, is rare.[1] In the adult stage the brown pigment begins to accumulate and shut out the inner transparent side, thus giving us an impression of light brown eyes. With the beginning of old age, the pigment again becomes rare and we see the blue eyes once more. We thus see how the very light shades, which include the cat's eye, are more frequent in childhood and old age, while many of them are masked in the intermediate stages. We then get only about 4 to 5 per cent cat's eyes which remain so from beginning to end. The eyes which are really brown, but which, owing to the very low accumulation of the pigment, appear as cat's eyes, go to increase the percentage frequency of this shade in the first and the last of our age groups. Otherwise, this shade together with the green is subjected to very little variation either by the factor of age or sex or difference of environment. Does this indicate a third racial strain apart from the light-eyed Indo-Aryans and the dark-eyed Dravidians? Very probably, it is a strain brought by the Aryans, who themselves were not a pure stock but had mixed more or less freely with the Persians and Iranians. This conjecture is strengthened by the Jewish or Parsee type of nose seen among the Chitpavans. It is generally not a perfect specimen of the Jewish type of nose or its more marked variety the Parsee nose, but is a straight nose with rather thick nostrils with the tip turned downwards. It resembles more the Jutish nose, which according to Ripley is similar to the Jewish nose.[2] (This type of nose has been classed as *oriental* by E. Fischer, thus distinguishing it from the prominent Jewish type. Cf. Fischer—Schwalbe, Anthropologie, pp. 171-172.) Neither is the Dravidian element a pure one. There seems to be a pre-Dravidian mixture as indicated by flat snub noses and wide nostrils seen in the case of some Chitpavans. It would thus seem that the Aryan and the Dravidian elements take a great share in the formation of the physical type of the Chitpavan of to-day, with Semitic and pre-Dravidian strains as minor factors.

We need not consider here the sweeping generalisation of Risley, in which he calls the people of the western coast Scytho-Dravidians. His chief argument is based on the comparative broad-headedness of all the coast people, but his results are based on very meagre data, his

(1) R. C. Punnet : *Mendelism*, pp. 205-206.
(2) Ripley, op. cit., pp. 316, 332.

measurements not including more than a hundred cases in any instance. The history of the people, the Chitpavans, the Saraswats, the Coorgs etc., has no record showing a Scythian connection and the matter of the cephalic index requires a more careful and extensive investigation. The communities of the west coast differ materially from the others in their social customs and usages. They may be related racially, but the problem has not been solved satisfactorily by Risley's work on the cephalic and nasal indices. Historians and ethnologists are not sure what people the Scythians definitely were, though they are attributed a Mongolian origin. The exclusion of Aryans from the country south of the Vindhyas seems to be an unjustifiable procedure, not warranted by physical facts seen to-day and long-standing tradition of generations. The so-called Aryan features are seen in southern communities as well as in the northern ones, if not in the same frequency.

I have already stated why I was inclined to stress the eye-colour. It was as good a measurement as any and no work had been done on it upto now. The Chitpavans are noted for this one feature and with a definite knowledge of the eye-colour, it would be easy to correlate other data, however meagre, which had already been collected for this community. We have already considered the possible races that go to contribute towards the Chitpavan community of to-day with the help of the evidence collected in this field, but one interesting fact remains to be noted and accounted for, if possible. In the youngest members of this community, the darkest shades predominate with an overwhelming majority and this fact seems to contradict the general observation about pigmentation. On the strength of the information supplied to me by the mothers, which should be accepted guardedly, dark-eyed children have not been reported to develop light eyes as they grow. The reverse has, however, according to the same source of information, been often the case. If this is true we have to assume, that the dark-eyed element is slowly gaining ground, proving a dominant characteristic in the Mendelian sense, the cat's eye remaining constant. But we cannot adequately explain this sudden dominance in one generation (Cf. the percentage frequency of the dark eye in the different age groups). A closer study of families and individuals is needed to solve this puzzle of the intensity of pigment in the younger people completely. (The phenomenon must be grouped among those known technically as " Dominanz-wechsel " in Mendelism).

We will now proceed to deal with the few cultural peculiarities of the Chitpavans which have already been described before. The ceremony of Boḍaṇa remains a mystery. As far as I know there is nothing like it in the other Brahmin communities or in the Kunbi community in the Konkan. From its description and as it is usually

carried out, it appears to be a form of virgin worship. The one small girl that is invited gets twice as much money (दक्षिणा) as the other married ladies, and is said to represent the goddess Pārvati or Yogeśwari in her unmarried form. At present the only significance of the ceremony is to avert evil of all kinds. It is performed in any season and at any time, the only inauspicious occasion being the time when there has been a recent death or a birth in the family. But this is a taboo which is common to all ceremonies. There is however one more taboo and that is that a woman bearing a child in her womb is neither to see the ceremony performed, nor can she take part in it. Her participation in the performance of the rite is supposed to bode evil for the child which is to be born. The same taboo is observed for the Mahalaxmi worship, which too is a feature peculiar to the Chitpavans.

Mahalaxmi is worshipped by every married girl for the first five years of her married life. The first Pūja begins on the first Ashṭami (8th day) of the month of Aśvin. The last Pūja is on the second day of the Divali festival, i. e. on the fourteenth day of the dark half of Aśvin. In the morning a few small pebbles are worshipped as goddesses while a few experts make out of rice flour the head of the goddess. This head is stuck up on the mouth of a narrow-necked water jar (घट) and in the evening the image is set up and fully clothed up and ornamented. Then follows a curious ceremony at which all the women blow into empty water jars till one of them is possessed by the spirit of the goddess. Everything that follows is exactly similar to the description of the Bodaṇa ritual given before. After midnight the fervour of the blowers is abated and in the early hours of the morning the women sleep or go quietly and sit at the feet of the goddess. There is a firm belief that in the evening when the dough image or face is set up, it looks like that of a young girl, at midnight it looks like that of a full-grown woman and then slowly ages, till in the morning it is so haggard as to look like a tired spent-up woman.

A pregnant woman is forbidden to worship or to behold the image in the Deccan. In the Konkan however the taboo is less rigorous. She is simply prevented from looking on when the head is being formed, which is done with great secrecy, lest some evil eye should spoil the beauty of the face. The women who worship the image tie a silken knotted thread to their wrists which is offered to the goddess at the end of the Pūja. They are to desist from sexual intercourse on that day. The dough head is given to the cow to eat the next day. Some tiny lamps and lumps are made of the same flour by all the women under this vow and are eaten up on the day the image is set up.

In the story of Mahalaxmi told by old women the Pūja is practised for the sake of wealth and prosperity, as well as to obtain the favour of one's husband. In the story a man is said to have worshipped the goddess as also two queens. But in practice, it is solely a ritual of women and I have never heard of men observing the vow.

Both the rituals seem to bear close analogy to the god-eating customs described by Frazer in his "Golden Bough".[1] They are rituals in honour of the all-mother Pārvati or of Laxmi, the goddess of plenty and fertility. They seem to be the counterpart of Astarte or Ishtar of the Babylonians and other mother goddesses of the ancient civilised world round the Mediterranean.[2]

In the ritual of Bodaṇa the small brass image of the Goddess is given food as an offering and that food is mixed together by the virgin invited and four or five married women. The image too is mixed with the rest of the food which is then given to all as sacred food and the image is then washed and worshipped. This is rather an unusual procedure and seems to symbolise the eating of the god[3] or spirit of vegetation. The Mahālaxmi worship is not that of Pārvati but of Laxmi, the goddess of wealth and spouse of Vishnu, the sustainer of the world. Brahman is the creative energy, Vishnu sustains and perpetuates the creation by continuous regeneration (Are Avatāras or incarnations symbolical of this universal idea ?) and Śiva is the force of destruction. Laxmi is the female principle which helps Vishnu in his task and hence she is the goddess of fertility and plenty. Gauri Pārvati has the same rôle, though she is the wife of the dread destroyer of the world. But this contradiction is removed if we remember that Śiva has another aspect emphasised in the Linga form, and so together with Pārvati, he is destroyer as well as the creator.

The worship of Mahālaxmi has many points of resemblance to the ancient ritual of the Aztecs of America.[4] These people made an image of their god by mixing various seeds and grinding them. This god was first worshipped with great ceremony and then eaten up. Although the image was formed by sacred virgins, men took part in the ritual. The idea that the goddess changes her form is also found among the Aztecs and a young girl is said to represent green *i. e.*, young maize. This goddess seems also to symbolise the spirit of vegetation and the three stages of the growth of young corn, its ripening and cutting down are represented by the three stages supposedly assumed by the dough-head of the goddess. All rites of this kind are followed by dramas of killing and resurrection. In Bodaṇa the resur-

(1) Frazer, loc. cit., pp. 479–494.
(2) Ibid., pp. 327, 348–56.
(3) Ibid., pp. 479–94, 482, 498.
(4) Ibid., pp. 488, 587, 681.

rection is symbolised by the act of keeping aside the goddess to be washed and worshipped again while the eating of the mixture of different foods symbolises the eating of the goddess. The same is symbolised in the eating of the dough lamps made out of the same flour used in the making of the image in the case of the worship of Laxmi. The act of the blowing air into the pots seems to represent the putting of the breath of life into the goddess. This idea is common among savages where a dying man breathes into the mouth of his successor, thus giving him his own spirit and power. Strict abstinence from sexual intercourse is also a feature common to such rites among the Aztecs. Lastly the taboo about pregnant women seems rather strange and cannot be explained.

This similarity of the rituals of Bodaṇa and Mahālaxmi with other and grimmer rites in no way solves the ethnological question which we have set ourselves, for the worship of virgins or goddesses as spirits of fertility is common to all races of man. A comparative study of such rites prevalent in India is needed to give a definite significance as cultural heritage to the two ceremonies we have been considering.

Amba Jogai is the goddess Pārvati of the sacred shrine at Mominabad or Amba Jogai in Hyderabad Deccan. It was a famous shrine and the Brahmins there were known for their learning and piety. The Kramavantas of Ashtāgar came from this part of Hyderabad. They were very much respected in the country and alliances with their families were much sought after by the Chitpavans and other Brahmins. Amba Jogai seems to have become the goddess of the Chitpavans after the 12th century when it was famed in Maharashtra as a sacred shrine and the home of learned Brahmins and when the Kramavantas brought its fame with them to Nasik, the Konkan and Kashi.[1] The conjecture of C. V. Vaidya,[2] that the goddess was adopted by the Chitpavans after the Peshwa had conquered Hyderabad seems to be wrong, for whereas almost all families in the Konkan gave Amba Jogai as their family goddess, in the Deccan many families worship the Mahālaxmi of Kolhapur or the Bhavāni of Tuljapur. Many families do not even know the name of Amba Jogai, which is never the case in the Konkan. The Chitpavans must therefore have adopted the goddess Amba Jogai in the Konkan long before they came into the Deccan, where afterwards they adopted the two above-named goddesses which were very famous in the Maratha period. I have given the approximate date of the adoption of the goddess by the Chitpavans as after 1200 A. D., because in a stone inscription found

(1) टिळ, अष्टागरांतील क्रमवंत घराण्याचा इतिहास.
(2) C. V. Vaidya, *Private Communication.*

in the Jogai village a grant to a temple is made by a Yadava Prince named Singhana in the year 1240. That period may thus be taken to be one of great prosperity of the town as a place of sacred temples.[1]

The few matriarchal customs and the prevalence of father-right are institutions which get a plausible explanation on the basis of the hypothesis of Aryan men marrying women of Dravidian stock. The men stuck to their patriarchal customs in all essentials and the women kept up their customs at least verbally, although they had no real significance in the social usage of the community in which they had been admitted. Ceremonies such as the first feeding of rice to a child and tying the cradle of the baby, which are to be performed by the maternal uncle were left undisturbed as the woman usually goes to her parents' house for delivery. Neither did this affect fundamentally the traditions of the Aryan settlers and the usages were therefore allowed to remain.

The hypothesis suggested by a study of the Paraśurāma myth, (cf. The Journal of the University of Bombay 1932, pp. 115-139), seems to be borne out by this review of cultural and physical facts. The Chitpavans present a cultural and physical complex made up of Aryan and Dravidian elements, which again presupposes an Iranian and pre-Dravidian mixture to a lesser degree. As the history of the Indo-Aryans and Dravidians shows, the former maintained an active intercourse with the Iranians after colonising India and before that period were united as one tribe in their wanderings from the cradle of the Aryans, while the latter living among the negroid pre-Dravidians centuries before and after the Aryan immigration could not escape racial mixture. To-day all these racial elements are mixed more or less thoroughly into a homogeneous community, but sometimes one sees types representing the four elements in their purity. The main components however are the Aryan and the Dravidian racial elements.

IRAWATI KARVÉ

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(1) *Arch. Survey Rep. Western Circle,* Vol. III, p. 49.

THE ORIGIN OF THE HORROR OF INCEST AND OF THE OEDIPUS COMPLEX

"Views which have developed out of the observation of Viennese neuroses between 1890 and 1920 prove themselves poor tools when applied to problems of totem and taboo, even when the application is made in a very clever way."[1]

—C. G. JUNG.

Why don't you marry your mother ?

For most men the reaction to such a question will be the same or it will vary within narrow limits. A person believing himself to be a wit may reply that his mother is too old or that he does not propose to allow the sins of his father to be visited on himself. But the average man will refuse to believe that you are serious when you put him a question of this nature. If, however, he is convinced as to your seriousness his reaction would most probably range from an indignant "What a question ?" to an expression of disgust and anger and, in some cases, to an unpleasant manifestation of pugnacity discomforting to the questioner. Such an attitude will at least enable the average man to evade some thinking which would be necessary in order to find an excuse for the sexual neglect of his mother and sister.

For the civilized man to-day the very thought of sexual relationships with his mother, sister or daughter is abhorrent. This attitude towards incest is so ingrained in him that he passes through life undisturbed by any curiosity regarding the general absence of incestuous relationships. He is helped in the maintenance of this attitude by the fact that all around him the same attitude prevails so that there are not many glaring exceptions to arouse his curiosity and disturb his equanimity. If some cases of incest come to his knowledge they are promptly disposed off by an expression of contempt for the freaks who are believed to be exceptions to the general rule. He takes it for granted that abhorrence for incest should exist since he believes that man must detest incest by his very nature. He assumes that the horror of incest is inborn.

The more thoughtful man rationalizes this conclusion. He asks: "Will all men possess the same attitude unless it is instinctive ? Would it be so universal, would it be so extensive in its hold through space and time and would it be so intense unless it is embedded in the mental make-up of man from his very birth ?" In this, as in the case

1. C. G. Jung. Art. on "Sigmund Freud in his Historical Setting" in *Character and Personality*, p. 55, Vol. I, No. I, Sept. 1932.

of many of his sentiments (like patriotism and race-prejudice) he seeks the sanction of heredity—of "Human Nature"—and probably of biological utility in order to sustain his belief. He further supports it by a refusal to notice facts which may disturb his poise. And if he cannot help noticing them he accounts for them by rationalized explanations. He is reluctant to know the truth since, for him, ignorance conduces to a happier mental state than knowledge.

But it will not require a very detailed acquaintance with ethnology to cause a violent disturbance in the placidity with which the universal prevalence of the horror of incest, through space and time is taken for granted. A study of the cultural history of various peoples with their varying beliefs, customs and institutions shows that the horror of incest is not as universal as it is supposed to be. Consequently, those who believe in horror of incest to be inborn on the ground that it has been universally prevalent throughont history and among all peoples, are not justified in their belief. Incestuous unions, socially condemned or disapproved of in some cases, and tolerated, approved of or even enjoined in others, have occurred in the past and continue to occur to-day. It is common knowledge that the Ancient Egyptian Pharaohs and the Ptolemies had brother-sister marriages and even to this day among royalty, incestuous unions are frequently allowed.[1] Marriage between brother and sister was "a real custom in ancient Egypt".[2] In Peru[3] and in Persia[4] such marriages existed in ancient times. Marriages between brothers and sisters were licit among the Syrians, Athenians and ancient Jews.[5] The old Prussians married almost any blood-relative except their mothers.[6] Among the Malasi "incest between brother and sister existed in olden days and there are certain family scandals told especially about the ruling clan. The passions repressed by tribal tradition breaks through even more violently and openly" to-day.[7] In the island of Kawai off the coast of New Guinea "a father may take his own daughter to wife"[8] A similar custom prevails in some of the Solomon Islands.[9] Among the Kalangs of Java mother and son union is considered commendable.[10] Among the Piojes of Equador the widow often takes

1. Edward Westermarck : *The History of Human Marriage*, Vol. II, pp.92 sq.
2. J. G. Frazer : *The Golden Bough-Adonis, Attis, Osiris*, Vol. II, pp. 214 sq.
3. R. Lowie : *Primitive Society*, p. 15.
4. G. E. Howard : *History of Matrimonial Institutions*, Vol. I, p. 125.
5. A. Forel : *The Sexual Question*, p. 164.
6. Edward Westermarck : *The History of Human Marriage*, Vol. II, p. 87.
7. B. Malinowski : *Sex and Repression in Savage Society*, p. 97.
8. R. Briffault : *The Mothers*, Vol. I, p 257.
9. Ibid.
10. Ibid.

her son and the widower his daughter in place of the deceased spouse.[1] Among the Eastern Tinne of North-West America instances of men united to their mothers, sisters or daughters are far from rare, and the Southern Indians of the Tinne stock occasionally cohabit with their own mothers and frequently espouse their sisters and daughters.[2] In Melanesia though a girl has sex-interests outside the home "they do not always preclude the occurrence of father-daughter incest".[3] Father-daughter incest is by no means rare among the Trobrianders[4] and there are among these people a number of cases of brother-sister incest.[5] Brother-sister incest is common among the Antambahoaka of South-Eastern Madagaskar. Such intercourse, far from being abhorrent, is believed to lead to fortune.[6] Among the Banyoro brother-sister and father-daughter marriages are permissible.[7] The King of Warna has in his harem even his sisters and daughters.[8] In Bougainville and Buka in the Solomon Group a father "not infrequently consorts with his daughter and begets children by her".[9] In Hawai, marriage between brothers and sisters was a well-known institution and father and daughter marriages have occurred among the chiefs.[10] In Marshall Islands instances of father-daughter and brother-sister incest are known.[11] In the Malay Archipelago marriages between brothers and sisters and between parents and children are said to occur in certain tribes.[12] In the southern districts of Minahassa the same kind of incestuous marriages were frequent.[13] Among the Karenes of Tenasserim incestuous relationships of the same type were not uncommon.[14] In some Brazilians tribes a brother and a sister often dwell together as man and wife.[15] Among the Wateita marriage between brother and sister is not infrequent though it is socially disapproved.[16] Among tribes of the lower Murray and lower Darling "incest of every grade continually occurs."[17] "A considerable number of instances

1. Westermarck : *The History of Human Marriage*, Vol. II, p. 83.
2. Ibid.
3. Malinowski : *Sex and Repression in Savage Society*, p. 73.
4. Ibid., p. 100.
5. Malinowski : *Sexual Life of Savages in North-West Melanesia*, pp. 474 sq.
6. J. G. Frazer : *Totemism and Exogamy*, Vol. II, p. 638.
7. Westermarck : *The History of Human Marriage*, Vol. II, p. 84.
8. Ibid.
9. Ibid., p. 85.
10. Ibid.
11. Ibid.
12. Ibid.
13. Ibid., p. 86.
14. Ibid.
15. Ibid., p. 88.
16. Ibid., p. 89.
17. J. G. Frazer : *Totemism and Exogamy*, Vol. I, p. 55.

are known", says Briffault "of tribes where incestuous relations habitually take place and are allowed, and such instances have doubtless abounded in the most primitive societies".[1] Among many Indian tribes of Central America "incest is said to be always practised when the eldest daughter accompanies the father for a few days into the mountains in order to prepare his maize bread for him".[2] Among peasants, "the attempts of father on daughter are very frequent. This seems especially to be the case among the Latin races. . . . In Rumania the occurrence of this type of incest is very common among peasants, and so it seems to be in Italy."[3] The German Gypsies allow brother-sister marriages,[4] and in France during the last century, it was not very uncommon for fathers "to live in concubinage with their own daughters."[5] In Europe among the lower classes of the population there is not infrequently "a complete absence of any conception of the immorality of incest."[6] And even among the higher classes intercourse between boys and girls of the same family is by no means rare.[7] Incest is common is Switzerland, especially among the inhabitants of isolated mountain chalets.[8] "In certain epochs the tendency to incestuous unions is remarkable as in the period of the French Rococo when it was introduced by suggestion on a large scale and manifested itself with alarming frequency".[9]

In addition to these instances, in certain cases incestuous intercourse has a ceremonial or religious significance as in the case of some defloration ceremonies in which the father is the person who undertakes defloration or in certain cases of *jus prima noctis* (as among the Kurnandaburi of Australia)[10] where the father of the bride is allowed access to her. Similarly, in Saturnalia and in annual or more frequent sexual orgies, "not only no relationship was respected but in many instances those persons expressly came together who on ordinary occasions were not permitted to marry."[11] Even among tribes which

1. Briffault, op. cit., Vol. I, p. 258,
2. Iwan Bloch : *The Sexual Life of Our Time*, p. 640.
3. Malinowski : *Sex and Repression in Savage Society*, p. 66.
4. Westermarck : *The History of Human Marriage*, Vol. II, p. 91.
5. Ibid., p. 200.
6. Iwan Bloch, op. cit., p. 639.
7. Westermarck : *The History of Human Marriage*, Vol. II, p. 201.
   As an illustration of the occurrence of incest among the higher classes may be cited the incest of Pope John XXIII and of Pope Alexander VI referred to by Huth in his *The Marriage of Near Kin*, p. 113, Footnote.
8. A. Forel : *The Sexual Question*, p. 402.
9. Iwan Bloch, op. cit., p. 640.
10. N. W. Thomas: *Kinship Organization & Group Marriage in Australia*, p. 144.
11. A. M. Huth : *The Marriage of Near Kin*, p. 21.

strongly disapprove of incestuous relationships in general "the act of incest is nevertheless positively enjoined in certain circumstances as a mode of ensuring good luck."[1]

The foregoing illustrations must have made it clear that incestuous intercourse, socially enjoined, approved of, tolerated or condemned, has been in existence in a considerable measure. The horror of incest is, therefore, far from universal and consequently universality cannot be invoked to support the belief that the horror is instinctive. As for the contention that the horror of incest is so great that only an instinctive reaction can possess the intensity of feeling which goes with it, we may say that in many of our sentiments the intensity of feeling is as great even though the contents of these sentiments are admittedly acquired. For instance, consider the love of the patriotic soldier for the King or the flag, the horror of the Victorian dame for short skirts and shingles or that of so many modern men for nudity and new ideas. Besides, the horror of incest (in its wider sense) attaches with equal intensity to the violation of all rules of exogamy irrespective of their nature.[2] The horror is the same though the distinctions regarding incestuous and non-incestuous unions are, as Wissler says, "variable and arbitrary."[3] For some people the horror is confined to intercourse between parent and child or brother and sister ; for some it extends to cousins ; and for some to whole totemic groups and tribes.

The belief in the instinctive nature of the horror of incest cannot, therefore, be justified either on the ground of universality or on that of intensity. Indeed these two characteristics are not at all the exclusive attributes of instinctive tendencies. The mere facts of universality and intensity of an attitude are not in themselves sufficient to enable us to conclude that all our reactions which possess these qualities are inborn or instinctive. Our habits often possess the same attributes. Man's desire to wear clothes is well-nigh universal and his reaction towards nudity is very intense (consider, for instance, the persecution of the Dukobhors) and yet no one can rightly ascribe this desire to instinct. Similarly, homosexuality is almost universally condemned and the feeling of aversion it arouses possesses great intensity; and yet to say that this attitude towards homosexuality is instinctive would be to ignore the fact that homosexuality forms a stage in the normal development of the sexual impulse.

But apart from these facts which point out the possibility of a non-instinctive explanation of universal phenomena, the alleged instinctive nature of the horror of incest may be challenged on another

1. J. G. Frazer : *Psyche's Task*, p. 57.

2. L. T. Hobhouse : *Morals in Evolution*, p. 145.

3. Clark Wissler, Art. on "The Integration of the Sexes—Marriage" in *Human Biology and Racial Welfare*, p. 282.

ground. The view that the horror of incest is instinctive cannot be reconciled with any plausible theory of instinct. Even if we admit for the sake of argument the wrong assumption that instinctive tendencies embody pre-determined definite objects, the horror of incest cannot be regarded as instinctive. What is the object to which the attitude of horror is attached? Do we possess an inborn knowledge of the relationship which we call incest and is the feeling of horror innately associated with that which is thus known as incest? Is there anything to show that from one's birth one's mother, sister or daughter is instinctively perceived in a totally different—and sexually repulsive—light as contrasted with other women? There is no evidence to induce us to believe that there is an inborn recognition of the concepts of such complex relationships as that of "motherhood", "sisterhood" or "daughterhood". Since such an instinct knowledge of relationships is not possible it is clear that no attitude—of horror or otherwise—can be inherently associated with incest.

The attribution of the horror of incest to an instinct must therefore be abandoned. As a matter of fact such a view has not been scientifically advocated by anyone because of the difficulties involved. But Westermarck has attempted to surmount these difficulties by arguing that the horror of incest is not itself instinctive in the sense that it is an inherited attitude towards sexual relationships of an incestuous kind but that it is natural in the sense that it is derived from a tendency which is instinctive—the tendency of persons living closely together to have sexual aversion for each other. "Generally speaking," he says, "there is a remarkable absence of erotic feelings between persons living closely together from childhood. Nay more, in this as in many other cases, sexual indifference is combined with the positive feeling of aversion when the act is thought of".[1] For Westermarck, therefore, it is not the fact of relationship that is responsible for the aversion towards incest. According to him it is a tendency by which the sexual sensibility of man becomes dulled with regard to those with whom he has been living in close proximity from earliest childhood. Since these latter persons are almost always the relatives of a man the horror of incest naturally exists with regard to the closest relatives.

In support of his theory he puts forward the argument that even the lower animals display aversion for sexual intercourse with close relatives. This argument has been adequately answered by evidence

1. Edward Westermarck: *The History of Human Marriage*, Vol. II, pp. 192 sq. This is also the view of Crawley (*The Mystic Rose*, Vol. I, p. 269) and of G. E. Howard (*The History of Matrimonial Institutions*, Vol. I, p. 130).

from the behaviour of the lower animals and the conclusion has been reached that animals do not possess any marked aversion to incest.[1]

But the main prop on which Westermarck supports his theory seems to be the alleged universal prevalence of the horror of incest among mankind.

As we have already seen the exceptions to the so called universality of the attitude are by no means inconsiderable. But in reply to the statement that the horror of incest is not universal Westermarck asserts that he does not see how the exceptions pointed out by various authorities affect the theory advanced by him. "I have no doubt", he argues, "that in the world generally homosexual practices are infinitely more frequent than incest; and nevertheless nobody would consider this frequency to be 'fatal' or even 'hostile' to the common view that there is normally a feeling of love between the sexes"[2]. Obviously, Westermarck is relying on a false analogy. The occurrence of incest is a direct contradiction of the theory that an aversion to incest exists, whereas the existence of homosexual practice does not imply a contradiction of man's heterosexuality. Homosexual practices and heterosexuality are not mutually exclusive while the occurrence of incest and the abhorrence for incest are definitely so. As a matter of fact a tendency towards homosexuality is believed to be one of the "component instincts"—as one of the those tendencies which exist during the earlier stages of man's sexual development. And yet the existence of such a tendency is by no means incompatible with the essential heterosexuality of man. Westermarck's analogy is, therefore, obviously faulty.

Westermarck further argues that "considering the great variability to which the sexual instinct is subject it is not astounding that cases of what we call incestuous intercourse sometimes do occur. It seems to me more remarkable that the abhorrence of incest should be so general and the exceptions to the rule so few."[3]

But is the occurrence of incest so very rare as Westermarck believes it to be? We have already noted a number of instances of incest about which we have definite knowledge. Abhorrence of incest

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1. Ralph de Pomerai: *Marriage—Past, Present and Future*, p. 64.

2. Westermarck: *The History of Human Marriage*, Vol. II, pp. 200 sq. Another erroneous argument adopted by Westermarck is that since Man acquired the erect posture he could be sexually attracted at a distance. But this is no argument in favour of an inherent aversion for those who are not at a distance. Because one can see the stars it does not mean that one must be blind to the flowers in his garden. Further according to Westermarck's own belief even among non-erect animals there is a sexual preference for strangers. If this is so the adoption of the erect posture has no bearing on the alleged sexual preference for strangers.

3. Edward Westermarck: *Origin and Development of Moral Ideas*, Vol. II, p. 373.

is not, therefore, as universal as it is supposed to be. Further, may it not be that, like all reactions which are socially condemned, the desire for incest wherever it is felt, is not acknowledged and that consequently the frequency of its occurrence may not be as little as Westermarck, with so many others, likes to believe ?

Arguing against theories which advocate a non-instinctive origin of the horror of incest, Westermarck says, "The theories in question imply that the home is kept free from incestuous intercourse by law, custom, or education. But even if social prohibitions might prevent unions between the nearest relatives, they could not prevent the desire for such unions. . . . . . . Nevertheless our laws against incest are scarcely felt as a restraint upon individual feelings. And the simple reason for this is that in normal cases there is no desire for the acts which they forbid." [1]

Westermarck seems to have taken the absence of desire for incestuous intercourse for granted. I am convinced that such a desire is far from being the rare phenomenon which Westermarck believes it to be, though because of the strong social condemnation attached to such desires and the consequent difficulty of obtaining candid admissions it is not possible to gauge its extent. But assuming for the sake of argument that there is an utter absence of desire for incestuous intercourse we need not infer from this that such absence must have a hereditary origin. I believe Westermarck's criticism of the theories of the non-instinctive origin of the horror of incest is based on a total misunderstanding of social influences. For most men, the prohibitions against thieving and murder are not essential since they pass through life without any desires for such acts. But this does not mean that it is an instinctive tendency in Man not to feel such desires. As a matter of fact for most men most of the social laws and prohibitions appear to be not burdensome at all. In these, as in the case of incestuous unions, social influences have been responsible in cultivating such habits of thought, feeling and action - and surroundings and environment are so adjusted to facilitate these habits that the individual does not feel the strain of social rules and prohibitions. So long as social rules do not come into direct conflict with man's impulses they need not necessarily be felt as prohibitions at all.

It may be remembered that the attitude of aversion towards incest does not exist from the earliest childhood, as it should if it was instinctive, but becomes established much latter. During their childhood brothers and sisters in the savage as well as the civilized world[2]

1. Westermarck : *The History of Human Marriage*, Vol. II, pp. 192 sq.

2. Westermarck : *The History of Human Marriage*, Vol. II, pp. 200 sq. Among the Azande it is quite normal for children to have their first sexual acts with their sisters, and only by admonitions and threats are their sexual

often play sexually together and it requires social influences and pressure for them to realize that there is something undesirable in what they do. Education and inhibition have, therefore, a great deal to do with the cultivation of the attitude towards incest.

Further, Westermarck seems to have overlooked the fact that not an inconsiderable number of adjustments are adopted even by grown up persons to avoid the temptation of incest e.g., isolation while dressing, sleeping, etc. and the custom of avoiding sisters and cousins which prevails among so many primitive peoples.[1] If instinct was relied upon it would not be necessary to separate the beds of boys and girls at or before the age of puberty when in their childhood they were allowed to sleep in a common bed. It is the assumption of the improbability of the existence of sexual activities in the child that is responsible for the fact that a common bed for children is considered permissible and it is the realization of the possibility of incest that leads to the adoption of precautions such as the separation of beds when childhood has passed. The precautions adopted by some peoples to avoid the intermingling of brothers and sisters—of male and female members of the household generally—indicates a fear of the possible occurrence of forbidden sexual relationships. Apprehension of incest has led even to the enactment of laws "again and again forbidding priests to have mothers or sisters to keep house for them."[2]

Again, Westermarck's belief that it is the fact of living in close proximity with each other that dulls the sexual sensibility of close relations does not explain all cases of the horror of incest. In some cases living in close proximity is not essential for the absence of sexual desires and the existence of the horror of incest. Among certain peoples, for instance in Melanesia, brothers and sisters are separated from earliest childhood[3] and yet the horror of incest is as great as in the case of others who do not separate them. The intensity of the feeling regarding totemic incest is very great though the people who belong to the same totem do not live in close proximity with each other from their earliest childhood. Now if in these cases a non-instinctive factor can be evoked as an explanation for the attitude towards incest, are we not entitled to demand that such possible explanations be eliminated before resorting to the instinct theory of the horror of incest in any form whatever ?

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desires directed in other channels. (Brenda Z. Seligman. Art. on "The Incest Barrier," *British Journal of Psychology*, January 1932.

1. J. G. Frazer : *Totemism and Exogamy*, Vol. II, p. 135.
2. A. M. Huth : *The Marriage of Near Kin*, p. 112.
3. Malinowski : *Sexual Life of Savages in North-West Melanesia*, p. 437. In China intense horror attaches to marriage between persons having the same family-name though these may be living hundreds of miles apart.

"The analogy of the lower animals", says Huth, "the habits of savage people, the records of crime, and the opinion of those whose business it is to portray human conduct are sufficient proof that whatever the origin of the prohibited degrees it is not due to any natural horror implanted in mankind".[1] Considering the evidence before us and considering also the theoretical objections against Westermarck's view we are entitled to conclude that the horror of incest is neither instinctive nor does it inevitably spring from any instinctive tendency.

But Sigmund Freud goes to the other extreme when he postulates the theory that Man is born with an unconscious desire to kill his father and marry his mother—that he is born with what he has chosen to call the Oedipus Complex. We will consider the origin of the entire complex later. Here our concern is with Freud's belief that not only do we not have an inherent aversion towards incest but that man has a positive innate tendency to commit incest. This desire for incest exists, according to Freud, in a repressed and therefore unconscious form, that is to say, a man does not normally become conscious of this desire, but does so only under exceptional circumstances. In support of his view Freud points out that the existence of this desire is manifested not only in the myths and legends of a great number of peoples but also in dreams in which incestuous wishes are symbolically expressed and fulfilled, and in the thought processes of the neurotic.[2]

But none of the arguments brought forward by Freud proves that the desire for incest is inherent. It may be that the myths and legends in which the desire is supposed to be imaginatively satisfied and the dreams and the thought-processes of the neurotic, are an indication of the universality of unconscious incestuous desires.[3] But this does not prove its instinctive nature since universality, as we have seen, is no proof of innateness. The evidence brought forward by Freud may show that the desire exists widely but it cannot prove that the desire is inborn.

In support of his theory Freud cites with emphatic approval Frazer's argument that if the desire for incest is not instinctive it will

1. A. M. Huth: *The Marriage of Near Kin*, p. 14.
2. Sigmund Freud: *Totem and Taboo.*
3. Myths and legends embodying incest are likely to have been invented, like so many others, for the purpose of maintaining existing moral standards. They are supposed to possess an educative value since they show the consequences of defying the moral code. In such cases the breach of a rule is taken only as a hypothetical case to illustrate the consequences of the breach and it may not indicate any general state of affairs in an earlier epoch and consequently have no historical significance at all. As for the satisfaction of incestuous desires in dreams—symbolically or otherwise—is it not a fact that a number of wishes, the origins of which are admittedly non-instinctive find satisfaction in dreams? How often do we dream that the person we dislike or hate, e. g., the schoolmaster or the boss, is injured or killed!

not be universally condemned as a crime. "The law," says Frazer, "only forbids men to do what their instincts incline them to do; what nature itself prohibits and punishes it would be superfluous for the law to prohibit and punish. Accordingly we may safely assume that crimes forbidden by law are crimes which many men have a propensity to commit. If there was no such propensity there would be no such crimes, and if no such crimes were committed, what need to forbid them? Instead of assuming, therefore, from the legal prohibition of incest that there is a natural aversion to incest, we ought rather to assume that there is a natural instinct in favour of it."[1]

Frazer's argument rests on two fallacious assumptions. The first is his belief that one must either have a natural desire for a thing or have aversion for it. He forgets that our desires and attitudes do not spring innately in a predetermined form—that giving direction to the innate impulses is an immensely important process in the development of the individual. The second assumption is based on an erroneous conception of legal prohibitions. From the fact that a desire which is never felt does not require laws to punish its occurrence, one cannot deduce that if there is a law against the overt manifestation of a particular kind of desire the latter must be universal and innate. It is not necessary that a desire should be universal and inborn to require a law against its overt expression. In every society there are laws against murder—including matricide. Are we to infer from this law that man has an inborn propensity to kill his mother?[2] Similarly the law against bestiality is universal. May we infer from this that man is not heterosexual but possesses an inborn propensity for bestiality? Clearly such an argument is absurd. The fact is that laws are not made as merely inhibitive agents of what are supposed to be instinctive propensities of man. They are meant as a guard against possibilities. Man's natural tendencies are initially loose and have no specific directions. They are capable of being directed in a number of channels. Some of them may be undesirable. It is to guard against the possibility of our impulses assuming these undesirable directions that laws are made and not merely as inhibitive agents which have the function of suppressing well-defined innate tendencies. Certain desires, regarded as socially harmful, are likely to arise and find expression in behaviour, under certain circumstances. Neither these desires nor the circumstances under which they are likely to arise are normal. And yet as precautions against the occurrence of these desires laws have to be framed and social attitudes formed. Man has no innate

1. J. G. Frazer: *Totemism and Exogamy*, Vol. IV, p. 97.

2. Such an assumption would be fatal to the Freudian view itself. For man will be, then, born with two antagonistic desires towards the mother—the one to love her and the other to kill her.

propensity to satisfy his sexual desire by having intercourse with any specific person. But it is possible that he may seek sexual gratification in incestuous intercourse. Hence the necessity of the law to prevent such a possibility.

The foregoing discussion shows that Freud is not justified in regarding the desire for incest as innate. It also shows us the way to the correct interpretation of the taboo on incest. The law against incest is adopted by man in order to guard against the possibility of man's sexual desires being incestuously directed. The mother, the sister and daughter are females and as such are capable of arousing sexual desires in the son, the brother or the father, possessing as they do the sexual characters necessary for the purpose of sexual attraction. It is the recognition of this possibility of incest rather than that of any innate propensity towards it, that is responsible for the law against incest.

But, it may be argued, why has it been thought necessary to impose such a taboo on a world-wide scale for centuries past? Why should Man have considered it necessary to prohibit incest at all? And how has this universal attitude of abhorrence towards incest come about?

Let us first consider why man has deemed it necessary to forbid incest.

Not an inconsiderable body of opinion inclines to the view that the incest taboo has been imposed because Man found that inbreeding is harmful to the species.[1] The advocates of this view hold that inbreeding results in the deterioration of the species and that Man having observed the evil effect of inbreeding thought it desirable for the benefit of the species to prohibit sexual intercourse between close relations.

This belief has been found to be lacking in a scientific basis. The assumption of the harmfulness of inbreeding has been thoroughly refuted, it being the considered opinion of scientists to-day (supported by convincing experimental evidence) that inbreeding in and of itself is not harmful.[2] But even if it was proved that inbreeding is harmful still the assumption that primitive man who is wont to find a magical cause for every evil and who, so often, does not even know the connection between sexual intercourse and procreation, studied the effects of inbreeding scientifically over a prolonged period of time thus

1. This view has been advocated by L. H. Morgan, Sir John Lubbock, Sir Henry Maine, Howitt and others.

2. W. E. Castle: *Genetics and Eugenics*, pp. 291 sq.
E. M. East: *Heredity and Human Affairs*, p. 154.
Wiggam: *The Fruit of the Family Tree*, p. 149.

adopting a method of study of social phenomena which is not applied without difficulty even to-day; and on the basis of his studies imposed a taboo which became universal, is on the face of it untenable.

Equally improbable is Elliot-Smith's theory that the taboo was imposed on the people by the earliest Egyptians who reserved the marriage of brother and sister as the distinguishing privilege of royalty.[1] If it was customary for men before the imposition of this restriction to have incestuous marriages it must have been one of the many customs and adjustments common to royalty and laymen alike. Why, then, should this particular mode of distinguishing the royalty from all other men have been adopted when a great number of other privileges could as easily be reserved for royalty as this one? If, however, the prohibition of incest existed before but was set aside as a special privilege for royalty, clearly the prohibition ante-dates the privilege and cannot be said to originate in it. Further how is the parent-child taboo to be accounted for on the basis of this theory? Smith's theory leaves these objections unanswered. But even if adequate explanations could be found for these objections, is it possible that the taboo which was imposed in order to supply a distinguishing mark to the royalty should persist through sheer inertia, with the same strength and in an unchanged form for thousands of years long after it has ceased to perform the function for which it was meant and after it has lost all its significance in the system of man's ideas and attitudes?

Smith's theory lacks even the merit which the former one possesses *viz.*, the recognition of the fact that the incest taboo was an outcome of social experience. The nature of the experience, as we have seen, is erroneously conceived, but the theory implies the essential fact that it is social experience from which the incest taboo is derived—that the attitude towards incest is not inborn but is one which is cultivated.

The question then will be, what kind of social experience was it which necessitated the imposition of this prohibition?

During the course of Man's past he found that certain organizations were indispensable for the solidarity of the group and for its continuation. Of these he found the family to be the most important group since it served as an adjustment in which a number of his most important needs were satisfied. The family was essential not merely for the protection and care of the offspring, but it was also required for the transmission of social expereince—as an agent through which the growing child learnt to equip itself for life and especially for its life within the group. It was not merely the growth and safety of the child in a physical sense that the family has to look after. It has been

1. G. Elliot Smith: *Human History*, p. 307.

one of the indispensable functions of the family to equip the child with the cultural heritage of the past so that the child may be enabled to face the world with the material and social adjustments evolved by man.[1] It was discovered that for the purposes of the group—with which the welfare and the very existence of the individual is inextricably bound up—the maintenance of a harmonious and prolonged family-life was indispensable. Not only this. It was found that if man's social heritage is to be adequately transmitted, those persons who are to impart and those who are to receive the products of social experience must stand in such a relationship with each other—must have such attitudes towards each other—that the transmission of culture may become possible. It was also found necessary that such attitudes should persist for a prolonged period of time and not cease with the physical maturity of the offspring—that the family, with these attitudes, should continue to exist even after the maturity of the offspring.

It must have been discovered during the course of Man's long and laborious process of learning that the occurrence of incest is a disruptive force in the family and to the system of attitudes which it involves, that it causes the disruption of the family long before the time when the individual can afford to dispense with the family since in Man psychic sexual maturity often precedes physical maturity by a considerable period of time. Incestuous relationships within the family are bound to create various complications which undermine the solidarity of that group. For instance, it will create jealousy. Or, it will create between the members who indulge in incestuous intercourse that sort of intimacy and partiality for each other as also a preference for relative isolation from the rest of the group, which will have unfavourable consequences for the family. More than that the occurrence of incest will destroy just those attitudes which are indispensable for the transmission of culture. As Malinowski says: "Within the family the sentiment between mother and child begins with the early sensuous attachment which binds the two with a deep innate interest. Later on, however, this attitude has to change. The mother's function consists in educating, guiding and exercising cultural influence and domestic authority. As the son grows up he has to respond to this by the attitude of submission and reverence. During childhood, that is during the extremely long period in psychological

1. Goldenweiser opines that transmission of culture in primitive society occurs through (i) objective material acquirements and (ii) from parent to child. (Goldenweiser: *Early Civilization*, p. 402). But even in the former the meaning of the acquirements and the mode of using them have to be transmitted by the older generation and particularly by the members of the family.

reckoning which occurs after weaning and before maturity, emotions of reverence, dependence, respect as well as strong attachment must give the leading tone to the boy's relation to his mother. At the same time also a process of emancipation, of severing all bodily contacts must proceed and become completed. The family at this stage is essentially a cultural, and not a biological workshop. The father and mother are training the child into independence and into cultural maturity; their physiological rôle is already over.

Now into such a situation the inclination towards incest would enter as a destructive element. Any approach of the mother with sensual or erotic temptations would involve the disruption of the relationship so laboriously constructed. Mating with her will have to be, as all mating must be, preceded by courtship, and a type of behaviour completely incompatible with submission,[1] dependence and reverence. The mother moreover is not alone. She is married to another male. Any sensual temptation will not only upset completely the relationship between son and mother but also indirectly that between son and father. Active hostile rivalry would replace the harmonious relationship".[2] Thus "incest must be forbidden because .. .. .. incest is incompatible with the establishment of the first foundations of culture. In any type of civilization in which custom, morals and law would allow incest the family could not continue to exist. At maturity we would witness the breaking up of the family, hence complete social chaos and an impossibility of continuing cultural tradition. Incest would mean the upsetting of age distinctions, the mixing up of generations, the disorganization of sentiments and a violent exchange of rôles at a time when the family is the most important educative medium".[3]

Brother-sister incest also would lead to a failure in the proper performance of the functions of the family. Those members of the household who practise incest will have a tendency to be partial towards each other and to be relatively isolated from other members of the family—a tendency which is detrimental to the interests of the family group and to life within that group. It will also lead to the failure of one of the chief functions of the family *viz.*, the cultivation of habits in which the impulses of the individual are inhibited, directed and sublimated in the interests of the group. The solidarity of the family

1. The willingness of the male to fulfil the wishes of the female in courtship must not be confused with the attitude of submission. The former is not a submissive attitude at all. If the son courts the mother he at once attains a footing of equality with her and his attitude becomes that of the dominant male.

2. Malinowski: *Sex and Repression in Savage Society*, pp. 250 sq.

3. Ibid.

may be further affected by the operation of conscious or sub-conscious parental jealousy and by another important factor, emphasized by Brenda Z. Seligman, *viz.*, the creation of rivalry between father and son on one hand and between brothers on the other.[1]

It is, therefore, the realization of the necessity of maintaining the integrity of the family that has been responsible for the incest taboo. It is a product of culture for the maintenance of culture. Through the slow process of social experience, after probably thousands of errors and payment of penalties for them and after a number of attempts at the discovery of the causes of these, Man must have found in incest the factor that is destructive of one of his most important and indispensable institutions—the more important in those times when the family served more fully all the biological functions attached to it and in addition the cultural functions which are now relegated to other agencies and institutions like the state and the school. The causal connection between incest and the disruption of the family must have been grasped, directly and indirectly, by the observation of a number of correlations through a long period of time. And with the progressive realization of the connection between incest and the disintegration of the family, a number of adjustments must have been introduced gradually leading up to the prohibition of incest after, perhaps, attempts at a number of other adjustments had been made as a solution of the problem and abandoned. The prohibition introduced by Man for his cultural needs has become universal and firmly established probably after passing through a number of vicissitudes, with a history of development which is common to so many generally accepted social adjustments.[2]

1. Brenda Z. Seligman. Art. on "The Incest Barrier: Its Rôle in Social Organization," in *The British Journal of Psychology*, January 1932, p. 260. The jealousy of the mother and sisters must also be reckoned with.

2. It is not difficult to understand how the attitude of horror towards incest is cultivated. Long before the child grows to its physical maturity he sees around him an entirely non-sexual attitude between parents and children and between brothers and sisters. Should he feel incestuous desires, they are promptly inhibited by admonitions and punishments the inhibition being facilitated by the fact that incestuous desires are felt, owing to the precedence of psychic maturity over physical maturity, at a time when they do not possess the overwhelming strength which springs from physiological need. All expressions of incestuous desires meet with the strongest condemnation from those whom the child loves, respects and fears. In addition to these inhibitive agents his own habits and sentiments help him in maintaining an aversion for incest. As he grows he becomes so habituated to perceive his mother and sister in a non-sexual light—he preceives them on a plane so remote from the sensation plane—that the stimuli of sight, touch, hearing and smell which are so potent in sexual selection fail to affect him so far as his mother and sister are concerned. If sometimes they do, the already established aversion for sexual

The horror of incest, therefore, can be accounted for as a non-inherited characteristic of man's mind which is acquired by every individual through cultural influences for cultural purposes.

But according to Freud the horror of incest is only one element of the conscious counterpart of the Oedipus Complex. This complex —to kill the father and marry the mother—is, for the Freudians the nuclear complex, one of the basic elements of man's mind on which so many of his attitudes and so much of his behaviour depend. To this complex they also attribute the origin of a number of human customs and institutions, including man's social organization, moral restrictions and religion. For them, " the beginnings of religion, ethics, society and art meet in the Oedipus Complex."[1]

It is not our purpose here to enter into a discussion as to whether or not this unconscious desire—to kill the father and marry the mother —exists in every human being and in the same form. Our concern is to inquire into the possible origin of such a desire if it exists. Dr. Freud has advocated a fantastic theory to account for the alleged universal prevalence of the Oedipus Complex. He believes that in the earliest times when Man had just evolved out of his anthropoid ancestors, these desires were conscious. The desires were an outcome of the conditions that prevailed in the primal horde, the Cyclopean family in which man was supposed to live in those times. In this horde the father was the strongest male and as such he monopolised all the women available, including his own grown up daughters, so that the sons—the younger men—were left without mates. The horror of incest was non-existent at the time hence the males consciously and freely desired their mothers. But in the fulfilment of their desire for their mothers the father was a formidable obstacle. Being jealous of these younger men—his sons—he expelled them all from the horde regarding them as his sexual rivals. These brothers united themselves into a brother-clan and ultimately killed the father in order to possess his women. Let us give a description of this tragic event, which is supposed to have occurred at the dawn of humanity, in the words of Dr. Freud himself. He says : " There is only a violent jealous father who keeps all the females for himself and drives away the growing sons......One day the expelled brothers joined forces, slew and ate the father and thus put an end to the father horde. Together they dared and accomplished what would have remained impossible for them singly. Perhaps some advance in culture like the use of a new weapon, had given them the feeling of superiority. Of course these

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thoughts or feelings in relation to the mother or sister prevents them from occupying consciousness.

1. Sigmund Freud : *Totem and Taboo*, p. 260. The same view is endorsed by Freud in *Civilization and its Discontents*, pp. 118 sq.

cannibalistic savages ate their victim. This violent primal father had surely been the envied and feared model for each of the brothers. . . . They hated the father who stood so powerfully in the way of their sexual demands and their desire for power but they also loved and admired him. After they had satisfied their hate by his removal and had carried out their wish for identification with him, the suppressed tender impulses had to assert themselves. This took place in the form of remorse, a sense of guilt was formed which coincided here with the remorse generally felt. The dead now became stronger than the living had been, even as we observe it to-day in the destinies of men. What the father's presence had formerly prevented they themselves now prohibited in the psychic situation of 'subsequent obedience' which we know so well from psycho-analysis. They undid their deed by declaring that the killing of the father substitute, the totem, was not allowed, and renounced the fruits of their deed by denying themselves the liberated women. Thus they created the two fundamental taboos of totemism out of the *sense of guilt* of the son and for this very reason these had to correspond to the two repressed wishes of the Oedipus Complex."[1]

The hypothesis, as postulated by Freud, may seem very attractive but when we try to work it out in the actual primitive conditions it seems absolutely untenable. It must be remembered that Freud speaks of the time when humanity had just emerged out of its ruder ancestry. Our knowledge of the conditions that prevailed at the time is far from complete but according to Freud himself the event referred to ante-dates all culture and social organization. When the event happened there was no human language and therefore no means of communicating thoughts in the human sense of the word. Communication was probably carried on by the perception of instinctive reactions *e. g.*, like the cry of the monkey. Instinctive reactions mainly served as the means of understanding other human beings. Man's ends were not only determined by his instincts but were also mainly satisfied by instinctive reactions. No typically human adjustments existed. Man acted on impulse. The behaviour of man was an outcome more or less wholly of external causation *e. g.*, activity for obtaining food was initiated either by the feeling of hunger or by the perception of food material. His behaviour was typically unintelligent. There was little or no conscious cognition of ends and the manipulation of means for the satisfaction of ends. There was no foreplanning, no forethought. The stimuli which aroused accused man's reactions were not separated from the latter by any great gulf of time. They dominated the whole mind for the time and demanded satisfaction at once so that the desire

1. Sigmund Freud: *Totem and Taboo*, pp. 235 sq.

and the reactions leading to its satisfaction occurred within a short period of time. The higher integrations typical of the human mind could not have existed at all or if they did they must have been in an extremely rudimentary form.

It is under such conditions, Freud wants us to believe, that the event which determined according to him the whole course of human development and which continues to determine so much of man's behaviour to-day, took place. Let us consider a few consequences of the Freudian doctrine so that we may be enabled to judge its plausibility.

During the times about which Freud speaks was there only one primal horde ? If so how was the species perpetuated when, through remorse, the brothers renounced the women after they had killed their father ? If there were other hordes whose females they mated with, two questions would arise. First, why should the expelled brothers have persisted in their desire for the women of their own horde in spite of such a formidable obstacle as the father instead of finding their mates from other hordes by stealing or other means. Surely their adherence to an unflinching desire for their own mothers could not have been due to any strong personal preferences since for the primitive man (to whom indiscriminate sexual intercourse is attributed by so many authorities[1]) there are no such preferences above the appetitive level. Small differences in sexual attractiveness are not likely to deter him from mating. Secondly, how was the Oedipus Complex transmitted to the succeeding generations if other hordes existed ? Are we to believe that the same event happened identically and simultaneously in every one of the hordes ? To believe this would amount to believing in a coincidence which is, on the face of it, impossible.

Again, are the circumstances which are supposed to have led up to the fantastic event postulated by Freud possible ? Freud has virtually postulated a general condition of mankind in which there was an utter absence of a provision for the satisfaction of man's sexual needs. But in nature such a condition is inconceivable. If it was the habit of the first men to live in primal hordes of the Darwinian type the instincts of men must have been so adjusted that their sexual needs did not remain unsatisfied. The monopoly of the females by the strongest male to the entire exclusion of every other male, could not have been a general condition of the primal horde for any length of time since such a state of affairs would involve a frustration of the sexual desires of the individual and a hindrance to the perpetuation of the species. Even granting that man lived in primal hordes it must be admitted that there was some mechanism by which his sexual needs were satisfied. Is

1. Morgan, Bachofen, McLennan, Lubbock, Frazer, Bloch, Muller-Lyer, Bauer and others..

there any reason why there should be an unwarranted disturbance in this natural balance by a sudden increase in the jealously of the old male ?

In assuming that the fierce old male's jealousy was responsible for the expulsion of the younger males Freud forgets that the primitive woman was nearly as strong as the primitive man and that she was not merely dominated by him in the choice of sexual selection but made her own choice to a great extent. If this is admitted I see no reason why the younger females should not choose the younger and more attractive males and vice versa. Would it not be possible for these young people to run away from the old male while he is asleep or away ? And if the young males are expelled would it not be possible for the young females to abandon the old male and join his younger rivals ?

Now suppose that the young males were expelled from the horde as assumed by Freud. Since each one of the brothers was driven away from the horde as he grew up it must have taken some years before a number of them, adequate enough to kill the old male, was driven away. Are we to believe that primitive man, who was incapable of any sustained intelligent pursuit of any end, nursed his grievance against his father and adhered to his passion for his mother throughout a prolonged period of time ? Again, these expelled brothers, driven away at different periods of time are not only supposed to have discovered and joined each other but are credited with organizing themselves into a group in order to take conjoint action against their father. They are supposed to have done this at a time when, ex hypothesi, social organization in any form whatever, did not exist.

Freud himself seems to have recognised the improbability of a common purpose holding the brother-clan together. He ascribes the group existence of the brothers to the cruder factor of sexual attraction among the brothers. It was no common purpose on which the organization of the brother-clan was based. It was homosexual love that held the brothers together.[1] If this was so we should expect certain corollaries following from such love. We should expect homosexual jealousy and consequent discord and a breaking up of the brother-clan since in the earliest human group social cohesion must not have been so strong as not to succumb to the slightest tension. We should also expect an aversion for or at least an indifference towards normal sexual relation-

1. Freud: *Totem and Taboo,* p. 239.

I assume that the brother-clan did not come into being only after the father was killed. It must have existed before if the union of the brothers, who were separated in age and consequently expelled at different intervals of time is to be explained.

ships since such is the tendency of homosexual love. With these corollaries we should expect the non-fulfilment of the desire of the brothers to kill their father—the non-accomplishment of the "deed".

Further, were the sons driven away at the first manifestation of sexual activities? If so they must have been driven away at a time when they were incapable of preserving themselves, since even for our earliest ancestors psychological maturity in sex preceded physical maturity by a considerable period of time.[1] How could the species survive under such circumstances?

We will touch one more point of psychological importance in connection with the postulated events. Freud says that the brothers had a complex attitude towards the father. They hated him but they also loved him and respected him. It was the attitude of love and respect that caused the remorse after they had killed him. Now if the love of the sons for their father was so strong as to lead them to renounce their coveted prize after they had already succeeded in acquiring it, is it not possible that the intensity of this love may also cause a softening of their heart when they were separated from their father for a long time? If mere separation did not change their resolve to kill him, the sight of him—his physical presence—after a long time should have produced a softening and disarming effect on the sons when they approached him in order to kill him.

But even if we assume that the fantastic event which Freud has imagined did actually occur, we have no reason to suppose that this solitary occurrence, however great the intensity of feeling it aroused and however profoundly it affected the generation which experienced it, could so modify the constitution of the human mind as to cause certain tendencies to appear and to become part and parcel of man's psyche. For establishing the hereditary transmission of the Oedipus Complex, Freud has assumed, besides the occurrence of the tragic fantasy of patricide, two more things. These are, first, the existence of a Mass-psyche—psychic and emotional continuity from one generation to another—and secondly, the inheritance of acquired characters. Is he justified in these assumptions?

The concept of a group-mind transcending the mind of the individuals who form a group has been advocated among others, by Bosanquet,[2] Bergson,[3] McDougall,[4] Le Bon,[5] and Trotter.[6] It is not our purpose here to enter into a detailed discussion as to the possible

1. C. J. Warden: *The Evolution of Human Behaviour*, p. 76.
2. Bernard Bosanquet: *Philosophical Theory of the State.*
3. Henri Bergson: *Creative Evolution.*
4. William McDougall: *The Group-Mind.*
5. Gustav Le Bon: *The Crowd.*
6. W. Trotter; *Instincts of the Herd in Peace and War.*

truth of the conception of a group-mind or a mass-psyche. But it may be pointed out that in assuming a mass-psyche the protagonists of the theory forget that a biological organism is indispensable for what is called a 'mind'.[1] For whatever be our difficulties in apprehending the exact nature of the relationship between body and mind, between the physiological and the psychological processes in an organism, one fact stands out unchallenged in spite of all philosophical speculations as to the nature of mind. It is this that body and mind are both attributes of a biological entity the existence of which is indispensable for the existence of a mind. Where a biological unit does not exist there can be no mind. This, in my opinion, is a strong argument against any theory of a group-mind over and above the minds of the individuals who compose the group. For there is no biological entity of the nature of a human being, which we can call a human group and to which we may attribute a mind as easily as we do in the case of a human individual. It is useless to argue that just as the cells in a brain which are themselves units form the higher integration which is termed a brain so also each individual human being goes to form a higher integration which may be termed a group. And just as we regard mind as a counterpart of a brain (or in a wider sense of the whole nervous system) so also we may regard the group mind as the counterpart of the group. There is no analogy between the brain and its cells on the one hand and a group-mind and individual minds on the other. The cells of a brain are not units in the same way as the individuals in a group are. Besides the cells have pre-determined functions to perform whereas the individuals in a group have not.[2] If the individuals in a group seem different with diffierent functional values, the distinction is not inherent but acquired since the same individual can be trained in a variety of ways to perform varied functions. Again, the individual is not part of the group in the same sense in which a cell is a part of the brain. The relationships between the cells of a brain are entirely different from those of the individuals in their group. There is no physico-chemical connection between the individuals in a group as there is between the cells of a brain. The relationships of the cells form a new kind of organization with processes and functions which are different from those of an individual cell but the group-mind has no new process or function which can be distinguished from those of the individual mind.

1. C. S. Myers opines that there is no distinction between body and mind, that body and mind are one. (L. T. Hobhouse Memorial Trust Lecture on "The Absurdity of any Mind-Body Relation," at University College, London, May 1932.)

2. A similar criticism may be levelled against Bergson's analogy of the bee and the bee-hive. (Henri Bergson: *Creative Evolution*, p. 175.)

The individual may be a unit of society but the individual mind is not a unit of any hypothetical entity called a group-mind. No doubt the individual's relationships with other individuals immensely influence the contents of the individual's mind. But the mental processes of the individual, even though influenced in their operation by the group, occur in the individual's mind only and not in any imaginary group-mind. The group as such does not think or feel or act[1] even if it affects all these processes of the individual's mind. McDougall, one of the staunchest advocates of the theory of a group-mind, is himself not prepared to grant to the group-mind a consciousness distinct from the consciousness of the individual minds which compose the group. He is not prepared to accept a duality in consciousness by accepting a " collective consciousness ". He argues that the fact of the individual's consciousness being used twice over—once as that of the individual and again as that of the group—is an insurmountable difficulty[2] in the way of the assumption of a collective consciousness. We may raise a similar objection against McDougall's theory of the group-mind and say that the functions and processes of the individual's mind are used twice over when the existence of a group-mind is assumed.

The idea of a group-mind, so essential to the Freudian doctrine of the origin of the Oedipus complex, has been rightly criticized and discarded by a number of authorities,[3] and Freud's Mass-Psyche is no longer supposed to exist by any competent anthropologist.[4]

But besides the assumption of a Mass-Psyche Freud's doctrine requires another assumption which has been definitely disproved. It is essential for his theory that we believe in the hereditary transmission, from generation to generation, of experience which has occurred during the existence of a single generation in the earliest period of human existence. We are to believe that modifications of the contents of the human mind which happened in that one generation of our remotest ancestors have become a characteristic of human nature. In other words we are to believe in the " inheritance of psychic dispositions "[5]—of acquired characters—in the Lamarckian view that acquired traits are transmitted by heredity from generation to generation. But biologists are

1. R. M. Maciver: *Community*, pp. 75 sq.

2. Wm. McDougall: *The Group Mind*, pp. 37 sq.

3. L. T. Hobhouse: *Social Evolution and Political Theory*, p 95. Wm. James: *Psychology—Briefer Course*, p. 199. Knight Dunlap: *Social Psychology*, p. 17. F. Giddings: *Studies in the Theory of Human Society*, p. 154. Carl Murchison: *Social Psychology*, p. 167. For an excellent discussion of the problem of the group mind see Morris Ginsberg's: *The Psychology of Society*, Chapter IV.

4. Malinowski: *Sex and Repression in Savage Society*, p. 155. In this connection it may be noted that Levy-Bruhl's theory of 'collective representations' has been thoroughly discounted. We find an able contradiction of the theory in J. Murphy's *Primitive Man*, Chapters IX and X.

5. Freud: *Totem and Taboo*, p. 263.

in agreement in rejecting the Lamarckian hypothesis and in concluding that acquired characters are not transmitted.[1] It is agreed that the germ-plasm of the individual which alone goes to make the new individual in reproduction, remains unaffected by changes in the somatoplasm. The modifications in the individual which occur in one

1. Weismann's work which struck such a fatal blow to the Lamarckian view-point has received corroboration and substantiation from the work of biologists. Even before the rediscovery of the Mendelian principles (in 1900) Lloyd Morgan had found "no conclusive evidence for the transmission of acquired habits." (*Habit and Instinct*, p. 325.) a view which he later endorsed in the Encyclopaedia Britannica (Art. on "Instinct" in 11th edition) by once again declaring in favour of the Weismannian interpretation of heredity. After the rediscovery of Mendel the Lamarckian view has been even more emphatically rejected. In 1908 J. A. Thomson wrote that no one was entitled to consider the transmission of acquired characters as a fact of inheritance (J. A. Thomson: *Heredity*, p. 165.). From the evidence at that time available he gave a verdict of "non-proven" to the claims of the Lamarckian hypothesis. (Ibid., p. 166). Since then no further advance has been made in support of the Lamarckian principles. The alleged verifications of the hypothesis have met with unfortunate ends. Griffith's experiment was found to be a coincidence; Pavlov had to withdraw his assertion about the inheritance of acquired traits and Paul Kammerer, whose experiments exercised some influence on biological thought for a time, had to commit suicide following a falsification of one of his important experiments. Other experiments, e. g. of J. W. H. Harrison, have been shown to be either unscientifically conducted or explicable in other ways, like the experiment of Wm. MacDougall (regarding the escape of a rat from a water-tank) which according to Jennings "can be otherwise interpreted." (H. S. Jennings: *The Biological Basis of Human Nature*, p. 344). On the other hand the work of biologists has caused the total abandonment of the theory of the inheritance of acquired characters. Most biologists denounce the theory in unequivocal terms. Castle accepts Weismann's view and cites an interesting experimental verification of it by which he shows that the transplantation of the ovaries of a black Guinea-pig into a white one did not affect the germcells produced by the ovaries. (W. E. Castle: *Genetics and Eugenics*, p. 66) Guyer does not believe in the transmission of acquired habits (Michael F. Guyer: *Being Well-Born—An Introduction to Heredity and Eugenics*, p. 258). Dr. and Mrs. Whetham hold a similar opinion (*The Family and the Nation*, p. 16.) For Conklin "almost all the evidence adduced goes to disprove the Lamarckian doctrine" (E. G. Conklin: *Heredity and Environment in the Development of Men*, pp. 239 sq.) Wiggam, one of the latest writers on the subject of heredity finds that upto now no incontestable case of the transmission of an induced or acquired character even in the higher plants and animals has been noticed. (A. E. Wiggam: *The Fruit of the Family Tree*, p. 84). Even the arch-exponent of heredity Sir Francis Galton found it extremely difficult to see how acquired traits could be hereditarily transmitted (Francis Galton: *Natural Inheritance*, p. 16).

While biologists have accepted the non-inheritance of acquired characters, many psychologists have also endorsed the same principle. "Psychologists," says Murphy, had been wary (even in the hay-day of Lamarck) of assuming the inheritance of acquired characters, but they have become

generation are therefore in no case hereditarily transmitted to the next.[1] Freud is thus left without any legitimate means of transmitting to the succeeding generations the experience which the original patricide involved. Even granting, therefore, that the fantastic event postulated by Freud did actually occur, it could not possibly have been the origin of the Oedipus complex and of the social organization, religion, morality and art of Man.

But, we may be asked : If you reject this hypothesis how else do you account for the Oedipus Complex ?

Though the lack of a plausible explanation in no way mitigates the unacceptability of a wrong theory, in this particular case we have an immensely more correct explanation to offer regarding the origin of the Oedipus Complex than the one postulated by Freud.

As we have already stated we are not here challenging or even taking into consideration the truth of the Freudian doctrine that the Oedipus Complex is a human psychological trait of universal prevalence.[2] We have restricted our field of inquiry to the origin of the

doubly so after Weismann's work." (Gardner Murphy : *A Historical Introduction to Modern Psychology*, p. 357). Stout is at least "very doubtful" about the inheritance of acquired traits (G. F. Stout : *Manual of Psychology*, pp. 493 sq.) Woodworth regards the Lamarckian theory as "gone by the board" (R. S. Woodworth : *Psychology*, p. 113). McDougall finds no evidence that environmentally induced characters ever become innate (Wm. McDougall : *The Group Mind*, p. 219). And profound scepticism regarding the theory has been expressed by philosophers like Bergson (*Creative Evolution*, p. 183) and J. S. McKenzie (*Outlines of Social Philosophy*, p. 37).

1. For a detailed discussion of the problem of the transmission of acquired psychic traits see the writer's thesis on "Instinct and Habit in Society", University School of Economics and Sociology, Bombay.

2. But we cannot help noticing one or two objections against the assumption that the Oedipus Complex embodies certain specific desires—the desire to kill the father and marry the mother. We have Havelock Ellis with us when we say that Freud is not justified in identifying the sexuality of the child with that of the adult male of our species (Havelock Ellis : *Studies in the Psychology of Sex*, Vol. II, p. 306). The early love of the child for the mother need not be supposed to lead to incestuous desires—to a form of expression typical of matured sex. Indeed we think that this early love need not be exclusively or even mainly sexual in character. We do not agree that the sensations derived from nutritive and protective reactions of the mother are purely sexual and do not belong to or at least partially derive from other spheres of satisfaction. We are not at all sure whether we should regard the sensation of touch as giving satisfaction owing to its association with sex alone and not due to its association with nutrition and protection. The love for the mother, therefore, need not have a sexual basis. As for the hatred towards the father, even if we assume that it has sprung from sexual jealousy alone it need not lead to the extreme reaction of having a desire to kill him though it may cause a sub-conscious joy at the father's death.

tendencies brought to light by Freud and we will not extend it by entering into a detailed discussion about the nature of Oedipus Complex and the desires involved in it.

We have already dealt with the problem of the horror of incest. We have now to consider the ambivalent attitude of the child towards the father and the agencies which lead to the suppression of the incestuous desires as well as those springing from the hatred for the father.

We believe that hereditary transmission is not at all essential to explain the existence of ambivalence towards the father on a very wide scale in mankind. The existence of ambivalence towards the father can be fully accounted for by the experience of the individual in an environment which leads to the growth of such an attitude.

It is obvious that for the child, from its earliest infancy, the family and the relationships that exist within it are immensely important. These relationships between parents and children and between the children themselves have to continue so long as the family continues and consequently the impulses of the individual have to be directed, controlled, inhibited or frustrated in the interests of the family. The impulses have to be adjusted in such a way that if they are not positively conducive to the happiness of the family, at least they must not lead to its disintegration. Now in the prolonged concourse of the members of a family, a variety of situations are bound to arise in which each member plays a rôle in satisfying, directing, frustrating or inhibiting the impulses of other members. Each member, therefore, comes into contact with others in a variety of psychological situations and relationships and consequently the attitude of the members towards each other are very complex. The nature of the attitude of each member towards every other member will depend upon the type of experiences in which the latter has figured. It is the behaviour of each member towards every other member, and its reactions which determine the attitude of the latter towards the former. If, therefore, an ambivalent attitude is found attached to the father it is because the father figures in experiences which are conducive to such an attitude.

During the course of its experience within the family the child finds that the father not only exhibits behaviour which prompts the child to love him but he also displays behaviour which evokes reactions of dislike and hatred. The father satisfies the child in a number of ways, *e. g.*, by showing tenderness and extending protection. But he also dissatisfies him. He thwarts the impulses of the child and insists on their inhibition and control not only in what he believes to be the interests of the child himself but also in those of other members of the family. The father controls to a great extent the educative and training functions of the family and figures prominently in those spheres

which require the exercise of authority and force. Hence very often he has to be an object of the child's anger and dislike. Thus the father's rôle in satisfying the impulses of the child leads to the cultivation in the latter of a sentiment of love for him, while his unpleasant part in controlling and frustrating the child's impulses leads to the growth of the sentiment of hatred. Hence a complex attitude of both love and hatred is built up.

I do not agree with Freud that sexual jealousy is the main cause of the latter attitude—that the child's hate of his father springs from his regarding him as a sexual rival. Though rivalry for the possession of the mother is certainly one of the factors leading to the sentiment of hatred, the rivalry is not sexual. The possession desired by the child is not principally sexual in its nature. The desire has its roots in other satisfactions specially those derived from the nutritive and protective functions of the mother. The child desires possession of the mother for these purposes and consequently his jealousy of the father is non-sexual.

The sentiment of hatred towards the father derives most of its strength, not from any infantile jealousy but rather from the subsequent experiences of the child. That the ambivalent attitude of the son towards the father is derived from experience not necessarily of a sexual nature, is a conclusion which is borne out empirically by Dr. Malinowski's investigations.[1] He has shown that in Melanesia where matriarchy prevails, an ambivalent attitude of love and hatred is attached not to the father but to the maternal uncle who has to perform all the educative and inhibitive functions of the father. The father, in that society, is regarded as a friend by the child since his rôle in relation to the child is of such a nature that it affords various kinds of satisfactions to the child (*e. g.* the father plays with the child and helps him in various ways) and does not involve functions which may create dislike and hostility in the child's mind.

It is clear, therefore, that it is not the reactions of a group of men to the occurrence of a hypothetical event transmitted through generations that are responsible for the attitude of ambivalence towards the father but that the attitude is built up by the experiences of the individual.[2]

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1. Malinowski: *Sex and Repression in Savage Society.*

2. This conclusion is further borne out by the fact that even the mother is the object of an ambivalent attitude to some extent. (J. C. Flugel: Art. on "Thories of Psycho-Analysis" in *The Outline of Modern Knowledge*, p. 389). I believe that every member of the family has an ambivalent or even a more complex attitude towards every other member of the family. The common life of the members of a family gives rise to a variety of contacts between the members in which various impulses are brought into play and adjusted

But it may be asked: How is the element of hatred repressed? Is not the repressive agent the remorse that followed upon the original crime committed by the brother-clan?

Dr. Malinowski's answer to this question would be that the repressive agency is supplied by the strong element of love which represses the weaker element of hatred in the complex sentiment which is built up in the child's mind in relation to his father. The incompatible element of hostility is subdued by the much stronger element of love and is not allowed to occupy consciousness.[1] To this we may add that a number of other habits—of thought, feeling and action—derived from social contacts and social standards help him in the repression of the feelings of hostility. A strong habit of thought is inculcated in the child from his very early existence that it is bad or sinful to be hostile in feelings or behaviour or even in thought, towards the parents—a habit which is strengthened by practical demonstrations of its utility which the child perceives when he suffers owing to his failure to follow parental advice and orders. But even the conjoint action of the sentiment of love and of other habits is sometimes incapable of preventing hostility from occupying consciousness. Not unoften when a child is frustrated in his desires we see or hear him expressing hostility, *e. g.*, by verbal disapproval, by wanting to strike or by expressing the wish that some harm may come to the offending party. It is only with fuller control under social influences that the overt expression and conscious feeling of hostility are definitely avoided.

Thus, it is the sentiment of love towards the father together with other socially inculcated habits of thought that are responsible for the repression of the feeling of hostility towards the father and not the collective remorse of the brother-clan which is supposed to have followed the hypothetical crime committed at the dawn of humanity. To assume the latter to be the cause of repression is to accept the absurd corollary that the psychological mechanism by which repression occurs did not exist in the human mind before the event imagined by Freud but came suddenly into being after the event.

Further, Dr. Rivers has shown that there may be complexes based on the repression of painful experiences which centre around the emotion of fear (*e. g.* claustrophobia). If repression, in such a case, could occur owing to the experiences of the individual and lead to complexes, may we not conclude that the Oedipus Complex also has its origin in the experience of the individual?

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leading to the building up of complex attitudes. Indeed, in the family or out of it, wherever a variety of contacts occurs and persists, a complex attitude is likely to be built up and some undesirable elements of the attitude are likely to be repressed.

1. Malinowski: *Sex and Repression in Savage Society*.

These considerations lead us to the inevitable conclusion that the origin of the Oedipus Complex is to be sought, not in the occurrence of a single fantastic event in the remote past, but in the experience of the individual as he grows up under familial and societal influences. Just as the necessity of maintaining the integrity of the family is responsible for the horror of incest so also is it responsible together with the sentiment of love towards the father for the repression of the hostile attitude towards the father. The system of psychological factors which has been termed the Oedipus Complex by Freud thus arises from the experiences of the individual in a particular kind of social setting in which the family is considered indispensable.

M. M. DESAI

This paper was written as a preface to the author's forthcoming play "The First Oedipus."

Since this paper was sent to the publishers I have come across Lord Raglan's book "Jocasta's Crime" in which the author holds that certain human taboos and institutions (the taboo on incest and the institution of exogamy) originated neither in instinct, nor in reason, nor in anything else but magic. I have not the time nor the space here to discuss the theory at length, but this much may be said that Lord Raglan, instead of solving the problem of the origins of certain human beliefs, customs and institutions, merely transfers it to the origin of magic itself.

Lord Raglan's theory leaves us with two equally unacceptable alternatives. We must believe either that reason plays no part in human life even to-day, or that it has suddenly come into existence only after the beliefs, customs and institutions considered by Lord Raglan had come into being in a mysteriously magical way and that reason did not exist before that time at all. Lord Raglan overlooks the fact that even by 'a process of gradual and unconscious development" (p. 53 "Jocasta's Crime") through which, according to him, human rules come into being, adjustments may be discovered or arrived at which may be considered highly intelligent if their ends are regarded as preconceived, and that just because of the "unconscious process" rationalized values may be assigned to the adjustments (e. g. the incest taboo must be observed because its breach leads to a failure of the crops) so that they seem 'magical' in origin even though they have a rational basis in the satisfaction of human social needs. I am convinced that the food that man has been eating for ages was not discovered and adopted by him because he evaluated every possible object in terms of its vitamin, protein and carbohydrate contents. But it happens that men do not habitually take poisonous food-stuffs and I do not believe that poisonous objects have been out of man's menu because by sheer accident they happened not to conform to his magical beliefs. I am convinced that in the early past man did not sit down one day to consider the benefits of a societal organization and, having found it desirable, proceeded to devise rules for the conduct of the members of the group. But I do not believe that all the rules that man has been following (*e. g.* regarding the safety of the individuals of the group) have originated in magical beliefs which had no relation to his needs.

Lord Raglan's own theory of the origin of the sexual taboos is almost as fantastic as that of Freud's, for it assumes that owing to a sudden excess in his fear of menstruous blood, man devised (very intelligently it seems) a means of satisfying two of his needs—to avoid women who were dangerous because of their menstruous blood, and to keep them at such safe proximity that they could be easily accessible for the satisfaction of his sexual needs. The theory may be temptingly simple (Prof. Elliot-Smith may take it to his bosom, regarding the Nile as the 'stream' which divided the sexes and explaining the royal exemptions from the sexual taboos by the divine nature of the Kings). But the theory can boast of much less scientific support than some of the theories which Lord Raglan has deemed ridiculously unscientific.

M. M. D.

Reviews

Mediæval India: Social and Economic Conditions. Being the substance of Four Lectures delivered in Urdu to the Hindustani Academy, Allahabad. By A. YUSUF ALI, I. C. S. (Retired). Oxford University Press: 1932.

Sir W. Marris started the Hindustani Academy at Allahabad, and his successors have also been endowing the young institution munificently and actively promoting its many-sided efforts to broaden and deepen cultural influences through the medium of the Hindi-Urdu Language. The backwardness of India is manifest at one end in its mass of illiteracy. It is no less manifest at the other end in the very poor and meagre general knowledge of Indian *intelligentsia.* The remedy for the latter is to induce recognised masters of their own subjects to give series of lectures popular and attractive in form, up-to-date in matter, and sound in the logical and scientific methods exemplified in their utilization of the steadily growing material of knowledge. The Academy has been fairly successful in securing the right type of lecturer and obtaining from him subjects he has made his own by years of devoted and fruitful study. The booklet before us (pp xii+51+ index 2) is a condensed presentation in English of four lectures delivered in Urdu, but is as fluent as if written directly in English. And Prof. Hearnshaw's Foreword is in just the tone calculated to recommend it to students of India in the world at large.

Mr. Yusuf Ali is a Surati gentleman who had a distinguished career at the Wilson College, in the days when Mackichan, Scott, and Welinkar were in their prime, and proceeded to Cambridge after graduation. He stood high in the I.C.S. competition, and his years of service were passed principally in the U.P., where he speedily rose and attained and adored the highest positions then open to an Indian. He retired early, because, we believe, his self-respect could not brook juniors being preferred to him for the prizes of the Service, merely because he happened to be an Indian. Had his career begun only a decade later, he might have been spared some of these experiences. But the advance of Indians to the highest positions in their own land has been steadily marked by such sacrifices along the route. Decade by decade, martyrs have dropped out, and these cases of glaring injustice have opened the doors wider year by year to higher and higher posts for their juniors. Nor have the majority of these Indian pioneers who have been baulked of

their due because of their race, borne any illwill against the British on that account. They have been philosophical, large-minded and experienced enough to know that where two races are thrown together, progress for the conquered can only be won thus and very slowly too.

Mr. Yusuf Ali is a gentleman of wide interests, ripe culture and deeply read in the literatures of many languages. He is a brilliant author whose English works have only one defect. Confident in the attractiveness of his theme, and the clarity of his own treatment of it, he loads his pages heavily with facts. But they are scientifically ascertained facts in their right places in the narrative or the argument, many of them interesting in themselves as well as representative. And he always gives full references. He is one of the best of the Indian exponents of the incalculable benefits India has derived from the British connection.

Turning to this the latest product of his pen, the author omits what writers on the period usually concern themselves with, viz., the imperial and other principal dynasties their wars and rivalries, their rise and decline. And he brings together what we generally miss in these common accounts, viz., the social and economic conditions and facts of the period. He defines the Middle Age in Indian History as closing in 1526 ; and beginning, where the Age of Shri Harshavardhana ended. He utilises almost all the known sources for the period, Sanskṛt as well as Persian, literary as well as archæological and numismatic, sculptures, paintings, temples, frescoes, and ruins he draws upon as well as travellers' accounts, poems, grants, inscriptions, and folklore. We only miss the Jain and Tantric Literatures of these centuries ; but the reason of course is that the special scholars themselves have not yet worked at these comparatively obscure branches sufficiently long, to place in the hands of the qualified reconstructor of the past authoritative editions and results free from the din and smoke of chronological and textual controversies. On the other hand, we have an unusually judicious and illuminating selection from the authorities utilised ; and the author's ripe judgment guided him aright when in the limited space at his disposal he decided against attempting a continuous description, aiming only at placing three generations out of the centuries in proper perspective. He has selected the generation of Shri Harsha, that of Rāja-śekhara, and that of Muhammad Shah and Feroz Shah Tughluq. All the same he manages to interweave a vivid tapestry of Rājput manners in their prime, and from the bewildering medley of costumes, features and complexions in the remains of mediæval art, shrewdly opines against those who hold that Pauranik Hindu society settled down into the layers familiar to us at a very early date.

At each of the three points focussed, the question of the mutual relations between the North and the South of India cannot but emerge. Students of Indian History are realising very slowly that Southern India (with its Aryan literatures in non-Aryan languages) is quite as important throughout the centuries as North India ; that the North shot ahead in wealth and population only during the Mughal Period, and that during many of the previous centuries and especially during the Middle Ages, the South was really the more important half of India. Our author notes, for instance, that Muslims entered the South from the seaports principally as traders, and their relations with the people were in consequence far more friendly in that part of India than in the North, where they entered as armed invaders for loot and conquest. But the lectures are far too pre-occupied with the North to give a proper view of the mutual relation between these two halves of our country.

On the whole, however, the birds' eye-view presented in this brief space is exceedingly well done, and the able and judicious use of the Samskṛt and Prakṛt sources is all the more remarkable as coming from a Muslim scholar. The young generation of Muslim *elite* who have grown up in an atmosphore surcharged with communalism may well take a lesson from this worthy representative of the day before yesterday ; who grew up moreover and had his first lessons in liberalism not at Aligarh or in North India, but in the purer cosmopolitan air of Surat and Bombay.

B. K. T.

Caste and Democracy. By K. M. PANIKKAR. Hogarth Press. 1*s*. 6*d*.

This publication is No. 17 of a series planned by the Hogarth Press entitled Day to Day Pamphlets. Mr. Panikkar has already distinguished himself so well by his historical and political studies on India that any words in justification of his selection for the present task would be an inexcusable impertinence. A pamphlet on caste and its implications for the growth of Indian democracy from his well-tried pen should attract more than ordinary interest from all students of current affairs. A distinguishing virtue of all effective pamphleteering is its emphatic and clear-cut expression of particular standpoints—not to say, a deliberate intolerance of all opposing views. It has to be recognised as an additional merit of this publication that Mr. Panikkar has practised this virtue in more than ordinary measure.

Mr. Panikkar has very wisely declined to be allured into the barren scholarship which seeks to explain and weigh the exact part which many obvious and obscure influences must have borne in the genesis of caste. Instead of these Pickwickian antiquities, he does well in concentrating on what is on the whole a just and penetrating analysis of the forces which have made for the persistence and marvellous resilience of this unique social structure. His words are hot with passion and denunciation as he lays bare the working of the three main supports of caste, namely (1) the "educational basis of Ancient India" which in reality was only an unparalleled fabrication for the promotion of ignorance and superstition in those classes which were likely at any stage to question Bramhin ascendancy and which Mr. Panikkar describes very appositely as "the central paradox of Indian culture—the co-existence of a high civilization with the crudest and most primitive superstitions;" (2) the Hindu civil and criminal laws the inspiring principle of which may be read in the following extract from the law-giver Vishnu—"The gods are invisible deities, the Brahmins are the visible deities ; the Brahmins sustain the world. It is by the favour of the Brahmins that the gods reside in the heavens ; a speech uttered by Brahmins never fails to come true . . . when the visible gods are pleased the invisible gods are pleased as well ;" (3) the "religious machinery" which made an effective use of promises of future births and lives, of philosophy which never wearied of decrying earthly interests, of excommunication. But Mr. Panikkar is not content merely with a scathing exposure of the canker which has ultimately undermined the moral and spiritual vigour of the whole of Hindu society, Brahmins not excluded. In his analysis, the Brahmin is no longer a deluded victim of an environment which placed grave temptations in his way and which evoked without much of a conscious adaptation on his part the weaker side of human nature. He is here represented as a scheming knave who prostituted all his gifts and the privileges of his unique position to build for himself a godlike ascendency on earth on the moral and intellectual degradation of millions of his co-religionists. "The social structure of caste" says Mr. Panikkar "has not been the spontaneous outcome of a historical evolution, the adaptation of a society to its surroundings. On the other hand, all through its history the conscious purpose of a group at work can be observed, and in its later developments there is no doubt that the caste system has been the attempted solution of fundamental social problems by an oligarchy of priests intent first on preserving its own power, and secondly, in keeping down for ever the Soodra and aboriginal castes over whom their sway had extended."

It is doubtful whether the scientific mind will acquiesce in this thesis of a deliberate purpose or conspiracy without considerable

reservations. The whole difficulty of a just interpretation originates in the fact that the words and sentiments of the Hindu scriptures are in places so alien—not to say, revolting—to the crudest concepts of justice and reasonableness entertained by the modern mind that it calls for more than a human effort to believe that they could ever have been formulated with sincerity or believed in with sincerity by the authors. Yet it is beyond dispute that this strange scheme of life known as Hinduism is not the product of the efforts of any single man or any single group of men in consultation. If analysis is carried along these lines, it will be evident that the Brahmin philosophy and scriptures were the products rather than the cause of our social conditions. Critics like Mr. Panikkar cannot be unaware of a mental process which modern psychology has done much to bring into prominence called "rationalization." Under the influence of this insidious malady of the human mind, whole philosophies have risen and masqueraded as unalloyed truth, when in fact they represented nothing but the blind instincts and semi-conscious desires of the authors seeking expression under legitimate forms. The Brahmin philosophy and scheme of life is but another evidence of the grip of this deadly psychological disease on the human mind. Their doctrines of Karma and Rebirth, their fantastic history and science, were perhaps after all as much a defence-mechanism against the assaults of their own better instincts and clearer reason as against those of the hostile humanity outside, ever addicted as it is to its strange passion for liberty, equality, and fraternity.

Whether caste gave birth to a psychological perversion and the psychological perversion in its turn reinforced caste or not, it can hardly be doubted that to-day caste exists only as a psychological perversion and nothing more. As Mr. Panikkar points out, the establishment of British rule has meant the equality of all men before law, the displacement of caste jurisdiction and authority by state jurisdiction and authority, legislative enactments to remove or moderate some of the absurd disabilities of caste, and the imparting of education on a secular and democratic basis. In other words, caste has ceased to have any functional importance in social life. And yet, the caste taboos continue as effective as ever. Unfortunately, Mr. Panikkar does not inquire into the causes of the present strength of caste. He is content to note the fundamental irreconcilability between the ideals of democracy and the realities of caste and to make the perfectly legitimate prediction that either caste will destroy democracy or democracy will destroy caste, the latter probability being more in accordance with the lines of all social evolution. Yet, his optimism would find a better foundation and his worthy dream would appear more sure of early realization if he had attempted an analysis of the

true character of the resistance which caste is likely to set up against its extinction. ..

The source of this resistance is a mental distortion which caste, deprived of every functional implication, has left behind it as its nemesis for the 20th century Hindu. Looked at from the lower end of the scale, this distortion is a seething inferiority complex from which each caste stirred by the breath of the democratic spirit and ideal has begun to suffer in the presence of every other caste deemed by tradition as higher in the social scale. Analysed from the higher end, the perversion presents itself as a persecution-complex, a high-strung state of fear and terror at the probable deprivation of a status. It has no basis in practical facts, and in moments of clearer vision may even be admitted as imaginary. But it is still a persuasion which with the higher castes is somehow the very substance of their self-regarding sentiment. The result is an unmeaning and futile struggle in which the assault and the resistance are earnestly bitter and passionate for the simple reason that the struggle touches and disturbs the instinctive, the emotional and the subconscious strata of the Hindu mind rather than the reasonable and the conscious. From the lower end are heard the shouts of past tyranny and fraud and the call for reparation. These shouts are met at the higher end with an elaborate defence of lurking and half-guilty desires—rationalised into theory in which every conceivable difference of dress, mode and manner of life is made out into an evident symbol of superior culture; and spurious history, biology and anthropology are invoked to justify an air of persecuted innocence. Two events which have occurred very recently may be cited as excellent illustrations of this perverted mental attitude. In Poona, while their farfamed political passions are more or less cold, nationalist Brahmins were recenly moved to a white heat of anger and organized protest by a casual dramatic sally of a solitary Non-Brahmin writer who lighted on three effective words to ridicule Brahmin influence over the ignorant and the illiterate. Again, only recently, the absurd pretentions of an antediluvian Brahmin drew more fire and venom from a leading non-Brahmin member of the Parliamentary Joint Committee than all the irresponsible rhetoric with which Mr. Churchill is regaling British audiences could have done. Verily, verily unless publicists like Mr. Panikkar diagnose accurately and drag out these lurking diseases of the Hindu mind, much of their effort at reform will remain misdirected and futile.

S. K. MURANJAN

Financial Democracy. By MARGARET MILLER & DOUGLAS CAMPBELL. The Hogarth Press. 4*s*. 6*d*.

The problems of Financial Democracy—an expressive name given by the authors to the management of joint-stock companies, are not fundamentally different from those of political democracy. The root of the difficulties in both cases lies in the first place in the selection of competent and honest leadership and in the second place in the development of effective protection for the people against the temptations of power and office. As in the case of political democracy, the critics have always been at their best in exposing the character and the sources of the malaise which has afflicted this part of our economic structure. But when they arrive at the other and the more important part of their work, the elaboration of constructive proposals to cure the defects their barrenness and failure are at once self-evident. The present volume is not an exception to this general experience.

A little reflection will show that this outcome is hardly surprising. For, ultimately, the problem presents itself as one of improving the level of ability and character in those who participate in the creation and control of our economic activities. The aid which law can give in this field must of necessity be largely of a negative character. The law can define more stringently and, to an extent, amplify the functions of the auditor. But it cannot compel the investor to study diligently and to act intelligently on the balance sheets framed by the auditor. The law can empower the courts to conduct a post mortem inquiry to assure themselves that a reasonable degree of diligence and skill has been exercised in the management of insolvent and unsuccessful companies and to inflict punishments for obvious derelictions of duty. But the law cannot devise any machinery by which the directors will be guided unerringly in their details of day to day business management. The law may promulgate certain obvious disqualifications for the office of directorship in joint-stock companies. But the law cannot lay down any conditions of age, sex, complexion, education, past experience and so on which in the aggregate may be said to constitute business ability. Still less can it enable a crowd of miscellaneous investors to acquire the perspicacity to detect business ability and the modesty or spirit of trust to give it a reasonably free hand. The law may strive to secure a greater diffusion of general knowledge and education among the people. But the law cannot—except within narrow limits—prevail on the companies to make a greater use of educated people in their business or persuade the investors to overcome their apathy and to exercise their rights at the general meetings of proprietors.

It would be however a grave mistake on the part of the apologists of the present order to abandon their efforts to improve on these faults. For, capitalism is at this moment almost on its final trial. It will court its own destruction if it should entertain the foolish hope that it can persuade the world to bear with its patent evils and incompetencies by holding out the fear of still greater evils and incompetencies from the new rival plans of economic organization. The authors have done well in suggesting a few legal remedies for the more remediable evils of company management. But the rehauling will have to be of a much more drastic character if capitalism and private initiative and enterprise are to hold their ground against the assaults of new and lusty economic ideals.

The book should be of special interest in this country at the present moment. For more than four years the Government of India have been promising the public thorough and comprehensive legislation to amend the Indian Company Law which has almost broken down in a very grave manner. The recent debacle of the Mill Industry in Bombay clearly proves that it cannot be delayed any longer without much harm to the economic structure of India.

S. K. MURANJAN

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CONTENTS

TRANSACTIONS

EQUILATERAL AND EQUIANGULAR POLYGONS IN SPACE

By

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Royal Institute of Science, Bombay

1. Apart from its general mathematical interest, the problem of the existence and construction of equilateral and equiangular polygons in space is of particular interest to the Organic Chemist as it throws light on the structure of closed ring compounds of carbon. Sachse[1] seems to have tackled it first in 1890 and has obtained valuable results, as also Mohr,[2] Derx,[3] Wightman[4] and other chemists; but no systematic mathematical treatment appears to have been given until 1929, when Brodetsky[5] discussed the question in some detail. The method used by him, however, is somewhat indirect and the discussion of the hexagon is incomplete. The following treatment is both simpler and more direct and does not require any mathematical equipment beyond elementary trigonometry and geometry. The different possibilities for the hexagon are discussed more thoroughly and results not noticed by Brodetsky are obtained. A purely geometrical explanation for the existence of the flexible hexagon is also given and is, of course, more satisfactory than the analytical discussion.

A simple method for constructing models to illustrate the results is also described.

2. The problem is to construct equilateral and equiangular polygons, which are not necessarily plane. In all cases we shall take each side of the polygon to be of length a, and each angle of the polygon to be $\pi - \theta$, so that each *exterior* angle is θ (given). Then A, B, C, D, ... being consecutive vertices, the lines AC, BD, CE, ... joining alternate vertices are each of length $2a \cos\frac{\theta}{2}$. Again the perpendicular from any vertex (*e. g.* B) on the line joining the two adjacent vertices (*i. e.* AC) is of constant length, viz. $a \sin\frac{\theta}{2}$ (fig. 1). Let $a \cos\frac{\theta}{2} = b$ and $a \sin\frac{\theta}{2} = c$. The diagonal joining any

pair of alternate vertices is accordingly of length $2b$. This simple fact is the basis of the constructions that follow.

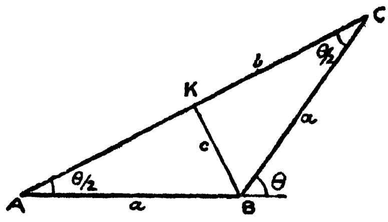


FIG. 1

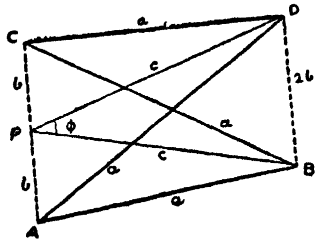


FIG. 2

3. For the triangle, we have $2b = a$ or $a = 2a \cos \dfrac{\theta}{2}$, giving $\theta = 120^\circ$. The plane equilateral triangle is thus the only possible solution.

4. For the quadrilateral, consider two isosceles triangles ABC ADC with common base AC of length $2b$ and each remaining side of length a. If the planes of the triangles are inclined at an angle ϕ to each other, so that $BD = 2b$, we get ABCD the required figure. (fig. 2.) If P be the midpoint of AC we have $BP = DP = c = a \sin \theta/2$; and therefore $\sin \phi/2 = \dfrac{b}{c} = \cot \theta/2$.

For ϕ to have real values, $\cot \theta/2 \leqslant 1$ and therefore $\theta \geqslant 90^\circ$. Thus for any value of the exterior angle between 90° and 180°, there is a definite real value of ϕ and we have a rigid form. $\theta = 90^\circ$ gives the plane square and no form is possible for $\theta < 90^\circ$.

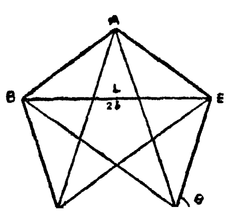


FIG. 3

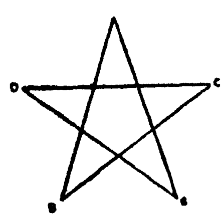


FIG. 4

5. For the pentagon ABCDE (fig. 3), consider first the quadrilateral BCDE (not necessarily plane) of sides $BC = CD = DE = a$ and $BE = 2b$, and the diagonals $BD = CE = 2b$. If L be the midpoint of BE, it follows from the congruence of the triangles BCE and EDB that $CL = DL$. Therefore L lies on the plane bisecting CD at right angles.

Similarly from the congruence of the triangles BCD and EDC, it follows that M the midpoint of CD lies on the plane through L perpendicular to BE.

LM is thus perpendicular to both BE and CD,

Further it can be seen easily that AL and AM are respectively perpendicular to BE and CD. $\therefore$ Either (i) the plane containing A, L, M is perpendicular to both BE and CD or (ii) the points A, L, M are collinear.

In (i) BE and CD must be coplanar and parallel; and then $LE = MD + a\cos\theta = \frac{a}{2} + a\cos\theta$. But $LE = b = a\cos\theta/2$.

$$\therefore \frac{a}{2} + a\cos\theta = a\cos\frac{\theta}{2}, \text{ giving } \theta = 72^\circ \text{ or } 144^\circ.$$

If $\theta = 72^\circ$, we have the plane regular pentagon as a known solution and there cannot be any other. For if A did not lie in the same plane as BCDE, AC and AD would not have the required length $2b$ *i. e.* $2a\cos 36^\circ$.

If $\theta = 144^\circ$, we have the regular five-pointed star as a known solution and there cannot be any other for the same reason (fig. 4).

In case (ii) where A, L, M are collinear, we have $AL = a\sin\theta/2$; $LM^2 = CL^2 - CM^2 = \frac{1}{2}(BC^2 + EC^2 - 2\,BL^2) - CM^2 = \frac{1}{4}a^2 + b^2 = \frac{a^2}{4}(3 + 2\cos\theta)$; and $AM^2 = AC^2 - CM^2 = 4b^2 - \frac{a^2}{4} = \frac{a^2}{4}(8\cos\theta + 7)$.

$$\therefore a\sin\theta/2 + \frac{a}{2}\sqrt{3 + 2\cos\theta} = \frac{a}{2}\sqrt{8\cos\theta + 7}.$$

This gives $4\cos^2\theta + 2\cos\theta - 1 = 0$.

$\therefore \theta = 72^\circ$ or 144°.

So that we again have BE and CD parallel and we get the two plane polygons obtained already as the only possible figures. For any other value of θ no polygon is possible.

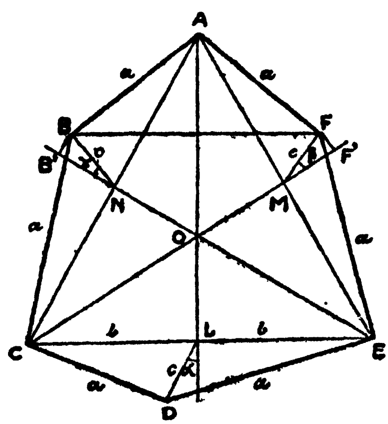


FIG. 5

6. For the hexagon ABCDEF, since each side equals a and each short diagonal equals $2b$, we have two equal equilateral triangles ACE and BDF of side $2b$, with the appropriate pairs of vertices at distances a apart.

Fix ACE first and let L, M, N be the midpoints of the sides CE, EA and AC respectively. Then DL = FM = BN = c = $a \sin \frac{\theta}{2}$ and they are perpendicular to CE, EA and AC respectively, (fig. 5). Let α, β, γ be the angles made by LD, MF and NB with the plane ACE, *i. e.* with the lines AL, CM and EN respectively, the angles being reckoned positive on one side of the plane and negative on the other. We may then express the conditions that

$$BD = DF = FB = 2b.$$

Let B′,F′ be the projections of B,F on the plane ACE. Then

$$B'F'^2 = OB'^2 + OF'^2 - 2\,OB'.OF' \cos 120^\circ.$$
$$= (b/\sqrt{3} + c \cos \gamma)^2 + (b/\sqrt{3} + c \cos \beta)^2 - 2\,(b/\sqrt{3}+c \cos \beta)\,(b/\sqrt{3}+c \cos \gamma)\,(-\tfrac{1}{2})$$
$$= b^2+c^2\,(\cos^2 \beta + \cos^2\gamma) + \sqrt{3}bc\,(\cos \beta + \cos \gamma) + c^2 \cos \beta \cos\gamma.$$

The projection of BF perpendicular to ACE = $c\,(\sin\beta \sim \sin\gamma)$.

$$\therefore BF^2 = B'F'^2 + (\perp \text{ projection})^2$$
$$= b^2 + 2c^2 + \sqrt{3}\,bc\,(\cos \beta + \cos \gamma) + c^2\,(\cos \beta \cos \gamma - 2 \sin \beta \sin \gamma).$$

But BF = $2b$.

Therefore,

$$\sqrt{3}\,bc\,(\cos \beta + \cos \gamma) + c^2\,(\cos \beta \cos \gamma - 2 \sin \beta \sin \gamma) = 3b^2 - 2c^2.$$

In the same way equating BD and DF to $2b$, we have

$$\sqrt{3}\,bc\,(\cos \gamma + \cos \alpha) + c^2\,(\cos \gamma \cos \alpha - 2 \sin \gamma \sin \alpha) = 3b^2 - 2c^2$$

and

$$\sqrt{3}\,bc\,(\cos \alpha + \cos \beta) + c^2\,(\cos \alpha \cos \beta - 2 \sin \alpha \sin \beta) = 3b^2 - 2c^2$$

We may write these as

$$p\,(\cos \beta + \cos \gamma) + q\,(\cos \beta \cos \gamma - 2 \sin \beta \sin \gamma) = 1. \quad (1)$$
$$p\,(\cos \gamma + \cos \alpha) + q\,(\cos \gamma \cos \alpha - 2 \sin \gamma \sin \alpha) = 1. \quad (2)$$
$$p\,(\cos \alpha + \cos \beta) + q\,(\cos \alpha \cos \beta - 2 \sin \alpha \sin \beta) = 1. \quad (3)$$

where $p = \sqrt{3}\,bc\,/\,(3b^2 - 2c^2) = \sqrt{3} \sin \theta\,/\,(1 + 5 \cos \theta)$. (a)

and $q = c^2\,/\,(3b^2 - 2c^2) = (1 - \cos \theta)\,/\,(1 + 5 \cos \theta)$. (b)

Note that $p^2 = 2q^2 + q$. (c)

The values of α, β, γ obtained from (1), (2), (3) will fix the hexagon required.

The equations are obviously satisfied if $\alpha = \beta = \gamma$, and

$$2p \cos \alpha + q\,(\cos^2\alpha - 2 \sin^2\alpha) = 1$$

giving
$$\cos \alpha = \frac{-p \pm \sqrt{p^2 + 6q^2 + 3q}}{3q}$$
$$= -\sqrt{3} \cot \frac{\theta}{2} \text{ or } \frac{1}{\sqrt{3}} \cot \frac{\theta}{2} \text{ from } (a), (b) \text{ and } (c).$$

6(1) If $\theta < 60^\circ$, $\cot \theta/2 > \sqrt{3}$ and so both solutions are inadmissible as they would give imaginary values for α.

6(2) If $\theta \geqslant 60^\circ$, the second solution gives a real acute value for α, but the first one is inadmissible unless $\left|\cot \theta/2\right| \leqslant \frac{1}{\sqrt{3}}$ *i. e.* unless $\theta \geqslant 120^\circ$.

6(3) $\theta \geqslant 120^\circ$, both values of $\cos \alpha$ are admissible.

Thus if θ lies between 60° and 120°, there is one hexagon for each value of θ, with $\alpha = \beta = \gamma$; and if $\theta \geqslant 120^\circ$ there are two such hexagons, [see figs. 6 (a) and 8, and further geometrical discussion in §9].

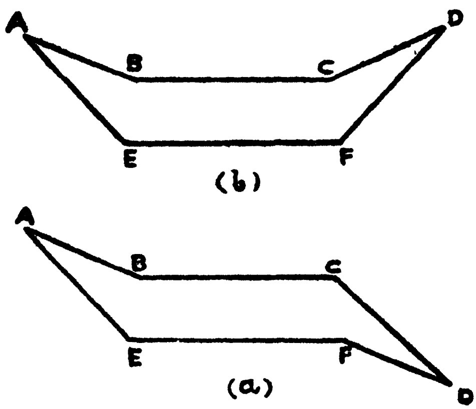


FIG. 6 (a) & (b).

7. To investigate the existence of hexagons for which α, β, γ are not all equal, we proceed as follows :

From equations (1) and (2), taking (a), (b), (c), into account we obtain,

$$\frac{\cos \gamma}{\sin \alpha - \sin \beta - p \sin (\alpha - \beta)} = \frac{\sin \gamma}{(q+1)(\cos \alpha - \cos \beta)}$$

$$= \frac{1}{p (\sin \alpha - \sin \beta) + q \sin (\alpha - \beta)}$$

Putting $\alpha + \beta = 2x$ and $\alpha - \beta = 2y$, these reduce to

$$\frac{\cos \gamma}{2 \sin y \cos x - 2 p \sin y \cos y} = \frac{\sin \gamma}{-2 (q+1) \sin x \sin y}$$

$$= \frac{1}{2p \sin y \cos x + 2q \sin y \cos y}$$

$\therefore \sin y = 0$ *i. e.* $\alpha = \beta$ or (4)

$$\frac{\cos \gamma}{\cos x - p \cos y} = \frac{\sin \gamma}{-(q+1) \sin x} = \frac{1}{p \cos x + q \cos y} \tag{5}$$

Eliminating Υ and using (a), (b), (c) we have

$$3q(q+1)\cos^2 x - q(q+1)\cos^2 y + 2p(q+1)\cos x \cos y = (q+1)^2$$

$$\therefore q+1 = 0 \textit{ i.e. } 2 + 4\cos\theta = 0 \textit{ i.e. } \theta = 120^\circ \qquad (6)$$

or

$$3q\cos^2 x - q\cos^2 y + 2p\cos x\cos y = q+1 \qquad (7)$$

Putting $\alpha + \beta$ for $2x$ and $\alpha - \beta$ for $2y$, this becomes

$$\frac{3q}{2}\left\{\cos(\alpha+\beta)+1\right\} - \frac{q}{2}\left\{\cos(\alpha-\beta)+1\right\}$$
$$+ p(\cos\alpha + \cos\beta) = q+1$$

or $p(\cos\alpha + \cos\beta) + q(\cos\alpha\cos\beta - 2\sin\alpha\sin\beta) = 1$ which is identical with equation (3).

This is a surprising and unexpected result and means that equations (1), (2) and (3) are not all independent, but reduce to only two independent equations. We may, therefore, assign any value (within certain limits) to one of the angles, Υ say, and we can find suitable values of α and β to satisfy the required conditions. The polygon so obtained is thus continuously deformable, having one degree of freedom, corresponding to the co-ordinate Υ.

To consider the limits within which Υ may vary, let us start with the symmetrical position in which $\alpha = \beta$.

Equations (1) and (2) of §6 show that we may regard α, β as the roots of the following equation in ϕ:

$$p(\cos\phi + \cos\Upsilon) + q(\cos\phi\cos\Upsilon - 2\sin\phi\sin\Upsilon) = 1$$

If then the roots of this equation are equal, we find

$$(p\cos\Upsilon - 1)^2 = (p + q\cos\Upsilon)^2 + 4q^2\sin^2\Upsilon$$

giving

$$\cos\Upsilon = \frac{p}{q} = \sqrt{3}\cot\frac{\theta}{2}$$

$$\text{or } \cos\Upsilon = \frac{p(1-3q)}{q(5q+1)} = \frac{(4\cos\theta - 1)}{\sqrt{3}}\cot\frac{\theta}{2}$$

Neither of these values coincides with those obtained for $\cos\Upsilon$ (or $\cos\alpha$) in §6, which shows that the form obtained there, with $\alpha = \beta = \Upsilon$ is a distinct form and not a particular case of the deformable polygon, now obtained. The form in §6 is therefore rigid and non-deformable. Now considering that values for Υ must be real, we have

$$\cos\Upsilon = \frac{(4\cos\theta - 1)}{\sqrt{3}}\cot\frac{\theta}{2} \text{ if } 60^\circ \leqslant \theta \leqslant 120^\circ.$$

and $$\cos\Upsilon = \sqrt{3}\cot\frac{\theta}{2} \text{ if } \theta \geqslant 120^\circ.$$

In either case, it can be further seen that when α and β are positive γ is negative [fig. 6 (b).]

From the symmetry of the figure, we can now deduce that any increase of α leads to a decrease of β and vice versa; the corresponding value of γ has therefore a turning value in this position. This gives therefore the limits, within which γ (or α or β) must lie,

as $\pm \cos^{-1} \left\{ \dfrac{4 \cos\theta - 1}{\sqrt{3}} \cot \dfrac{\theta}{2} \right\}$ if θ lies between 60° and 120°,

and $\pm \cos^{-1} \left(\sqrt{3} \cot \dfrac{\theta}{2} \right)$ if $\theta > 120^\circ$.

If we vary γ, starting from this extreme negative position, one of the angles, α say, increases and the other decreases. When α reaches its maximum positive value, β and γ become equal both being negative. If γ increases still further, β continues to decrease and reaches its maximum negative value when γ becomes equal to α, both being positive; and so on.

8. We now consider equation (6) of §6 viz: $q + 1 = 0$ or $\theta = 120^\circ$. If we substitute this value in equation (5) of §6, we obtain $\gamma = 180^\circ$, α and β being perfectly arbitrary. The figure then consists of two equilateral triangles ABC, DEF, with A and D coincident and AB inclined at an angle of 60° with DE, the positions of the triangles being otherwise arbitrary. There are thus two degrees of freedom corresponding to the co-ordinates α and β.

9. We shall now obtain purely geometrical constructions for such hexagons, which give us an insight into their nature.

Let ABCD be a quadrilateral having AB = BC = CD = a and AC = BD = $2b$. Whether it is plane or skew, it can be easily seen that AB and CD make equal angles with AD. Take next an exactly identical quadrilateral AFED and superpose it on the first. If we now rotate AFED about the axis AD so as to make the angle BAF = $180^\circ - \theta$, we should obtain the required hexagon,

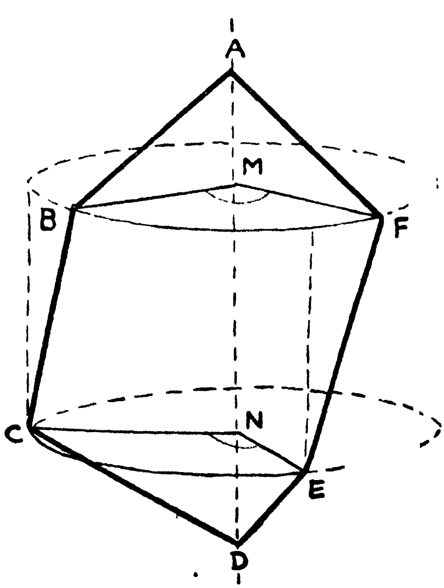


FIG. 7

provided angle CDE is also equal to $180^{\circ} - \theta$. That this is so can be seen from figure 7; for since AD and CD' are equal and are equally inclined to AD, BM = CN; therefore $\angle$ BMF = $\angle$ CNE and $\angle$ BAE = $\angle$ CDE. We have, therefore, that θ being given, we can construct a hexagon for *any* angle (within certain limits) between the planes ABC, ACD. In other words the hexagon is deformable without altering θ.

For the construction of the rigid hexagons, we take a cylinder whose base circumscribes the equilateral triangle BFD with side $2b$. If $\theta > 60^{\circ}$ but $< 120^{\circ}$, we obtain the hexagon A'BC'DE'F by taking points A', C', E' at a suitable height above the plane DFB on the generators diametrically opposite to D, F, B respectively. If $\theta > 120^{\circ}$, however, we can get another hexagon ABCDEF by taking the points A,C,E at a suitable height on the generators through D,F,B respectively, (fig. 8).

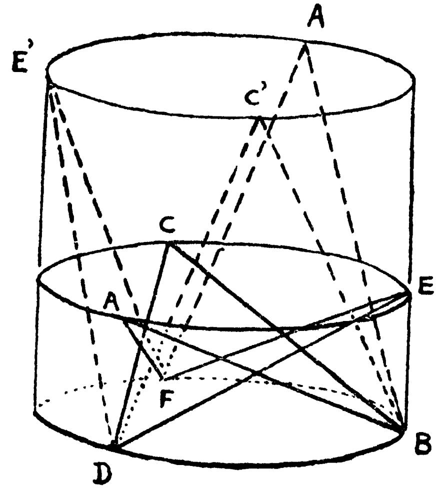


FIG. 8

We can also attempt to construct the rigid hexagon by the method of the last paragraph. The two quadrilaterals ABCD, AFED are then equal but not superposable; if ACD and AED are superposed, B and F lie on opposite sides of the plane. If AFED is now rotated through any angle, the arcs BF and CE cannot be equal if measured in the same sense; but they *may* be equal if measured in opposite senses, if AFED is rotated through a suitable angle. For a particular value of θ, there are therefore only one or two values of the angle between BCD and ABC which would give the required type of figure.

10. Models to study the properties of these polygons can be very simply constructed by taking a number of equal rigid wires bent in the middle at the required angle. If the ends of these are passed through close-fitting capillary tubes of suitable length, we can construct these polygons mechanically. Two such polygons are shown in plates I and II. I shows the rigid type of hexagon while II shows the flexible type. The diagonal triangles are shown by strings of different colours.

11. Polygons of more than six sides are not studied here as the degrees of freedom increase rapidly with the number of sides. For

PLATE I

I

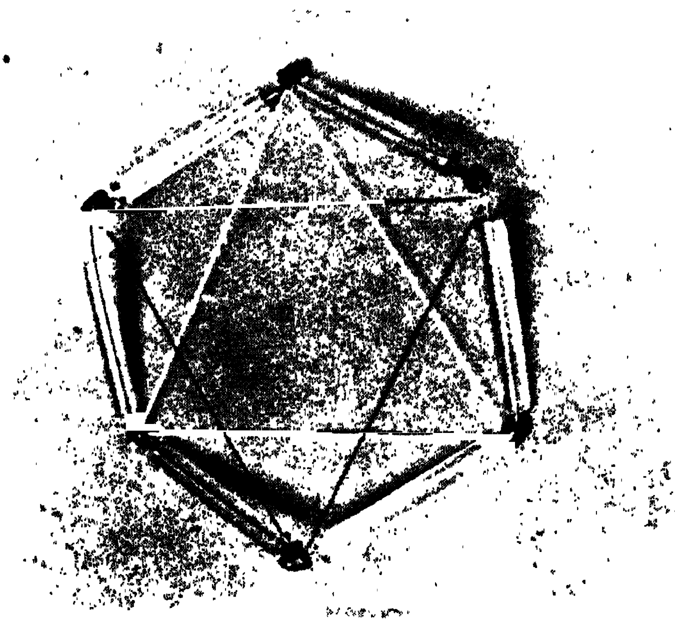
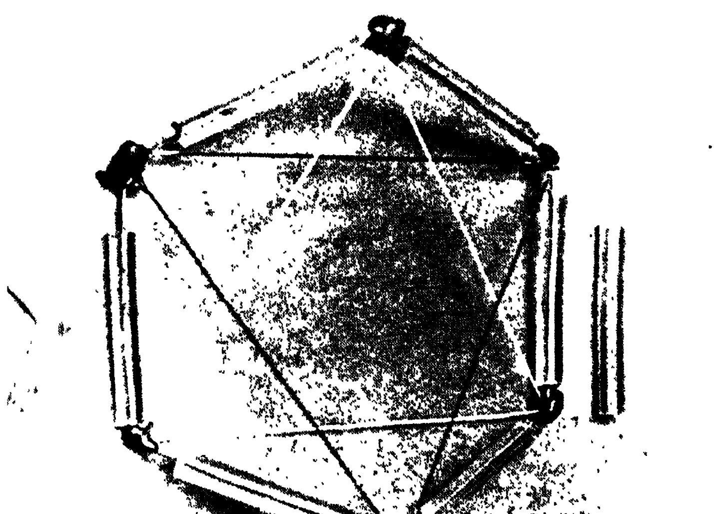


PLATE II



plane polygons of many sides, a reference may be made to a paper by Drew in the Journal of Chemistry and Industry of 30th June 1933.

In conclusion, I have to thank Dr. T. S. Wheeler for suggesting this investigation and Messrs. Dalal, Senior and Junior and Mr. Joglekar for help in making models and charts. I have also to thank Dr. S. Brodetsky for supplying me with a reprint of his paper.

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Royal Institute of Science
Bombay, July 1933.

THE REGULAR CONCAVE POLYHEDRA

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A polyhedron is said to be concave, when the whole of it does not lie on the same side of any face, and a concave polyhedron is said to be regular when all its bounding polygons are congruent and regular, all the dihedral angles (along the edges) are equal, and all the polyhedral angles have the same number of faces.

Cauchy has proved in one of his papers—"Recherches sur les polyedres" (Cauchy's Papers, second series, Vol. I) that if such figures exist then the innermost polyhedron enclosed by the faces must be regular and convex; and then by examining the five convex solids Cauchy proves that only four such figures exist. But the method used by Cauchy in this part of the investigation does not give a clear idea of the solid angles of these figures although it determines the form of the bounding polygons. The alternative method given in the present paper determines the number and form of the solid angles as well as of the bounding polygons of each solid and thus gives some idea of the whole figure.

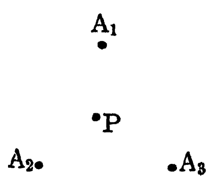
Cauchy's first result that the concave figures can be obtained from the five convex solids by producing their faces until they meet in a point or a line will be assumed. Also the following theorem which can be easily proved.

Theorem: If any concave polygon—plane or spherical—which does not consist of two or more smaller interlacing polygons, has all its sides equal and also all its angles equal, then the vertices are symmetrically arranged on the circumference of a circle and the innermost figure enclosed by the sides is a regular convex polygon. With the help of this theorem it can be shown by the method of spherical projection that if any polyhedral angle—convex or concave—has all its plane angles equal and also all its dihedral angles equal then the faces touch a circular cone, the edges lie on another coaxial circular cone, and the faces and the edges are symmetrically arranged round the axis. Such a polyhedral angle may be said to be regular and the axis of symmetry may be called the axis of the regular polyhedral angle.

It is easy to see that all the polyhedral angles of a concave regular solid are regular, and congruent with one another.

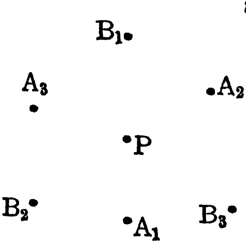
Now by Cauchy's theorem the innermost polyhedron enclosed by the plane faces of a concave regular solid is convex and regular and hence the concave solid must have an inscribed sphere. Also by definition all the edges are equal; the bounding polygons are regular and congruent and all the dihedral angles are equal. Reciprocating with respect to the inscribed sphere and remembering that the reciprocal of a regular polyhedral angle in this case is a regular polygon (convex or concave according as the polyhedral angle is convex or concave) we see that in the reciprocal figure all the dihedral angles will be equal, all the polyhedral angles will be regular and congruent, all the edges will be equal and the vertices will coincide with those of a regular convex solid. It follows that all the bounding polygons must be regular and congruent. Hence the reciprocal figure must be a concave regular polyhedron. We have thus proved that the vertices of all such solids coincide with the vertices of some regular convex solid, the edges of the concave figure coinciding with the edges or the diagonals of the convex figure.* Also the edges at any vertex must be equal, and must make the same angle with the central radius to that vertex. Hence to find the possible types of the concave regular solids we may take a vertex P of one of the 5 convex solids and find the systems of possible edges meeting at P.

In examining the five solids for this purpose it will be found convenient to represent the corners surrounding P by points in a plane perpendicular to the central radius OP, the distances from P remaining unaltered. The solid is supposed to be held with the vertex P turned towards the observer. The vertex opposite to P is not shown in the figure.



I. In the tetrahedron there is only one system of lines meeting at P, and this gives the solid angle P $(A_1A_2A_3)$ which belongs to the tetrahedron

II. In the cube there are 2 systems of lines at P.

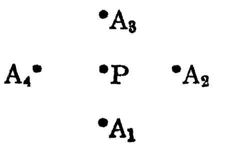


(1) PA_1, PA_2, PA_3 these give the solid angle P $(A_1A_2A_3)$ of the cube

(2) PB_1, PB_2, PB_3 these are the edges of a solid angle belonging to a tetrahedron and the complete figure obtained by drawing such lines at all the

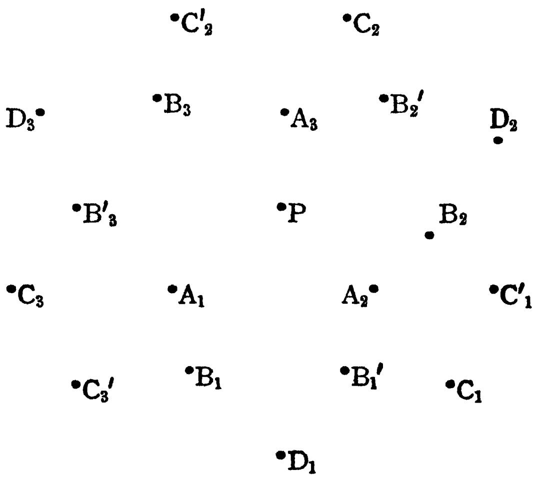
* This may also be proved directly by the method used in Cauchy's paper.

vertices consists of two interesting tetrahedra. This figure can also be obtained by stellating the octahedron.



III. In the octahedron there is only one system and the corresponding solid angle P $(A_1A_2A_3A_4)$ belongs to the octahedron.

IV. In the dodecahedron we get six systems of lines and the corresponding solid angles are



(1) P $(A_1A_2A_3)$ This belongs to the dodecahedron.

(2) P $(B_1B_2B_3,\ B_1'B_2'B_3')$ This consists of two solid angles P $(B_1B_2B_3)$ and P $(B_1'B_2'B_3')$ each of which belongs to a cube and the whole figure obtained by drawing such lines at all the vertices, consists of five interesting cubes.

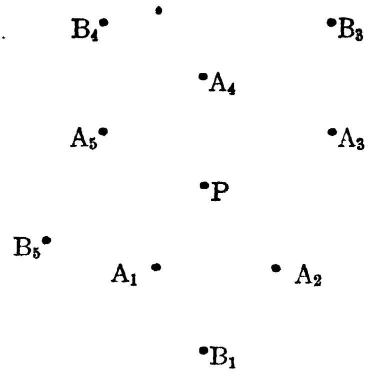
(3) P $(C_1C_2C_3)$ This belongs to a tetrahedron, and the whole figure consists of five intersecting tetrahedra. The twenty vertices belong to a dodecahedron and the twenty faces enclose an icosahedron.

(4) P $(C_1'C_2'C_3')$ This also belongs to a tetrahedron and the whole figure is the mirror image of the figure in (3).

(5) P $(C_1C_2C_3,\ C_1'C_2'C_3')$ This solid angle belongs to the combined system of 10 tetrahedra [(3) + (4)].

(6) P $(D_1D_2D_3)$ This trihedral angle belongs to the concave solid, called the great stellated dodecahedron. Considering the edges in the plane PD_1D_2 we see that each bounding polygon is a concave pentagon. Also the plane P D_1D_2, is parallel to a face of the dodecahedron. Hence there are 12 such planes and therefore the concave figure is bounded by 12 concave pentagons.

V. In the icosahedron there are two systems of lines at P, each of which gives 2 solid angles.



(1) P ($A_1A_2A_3A_4A_5$) This belongs to the icosahedron

(2) P ($A_1A_3A_5A_2A_4$) This is a concave solid angle belonging to the great dodecahedron which is bounded by 12 pentagons (as may be seen by considering the edges in the plane P A_1A_3).

(3) P ($B_1B_2B_3B_4B_5$) This convex solid angle belongs to the small stellated dodecahedron which is bounded by 12 concave pentagons (consider the edges in the plane P B_1B_2).

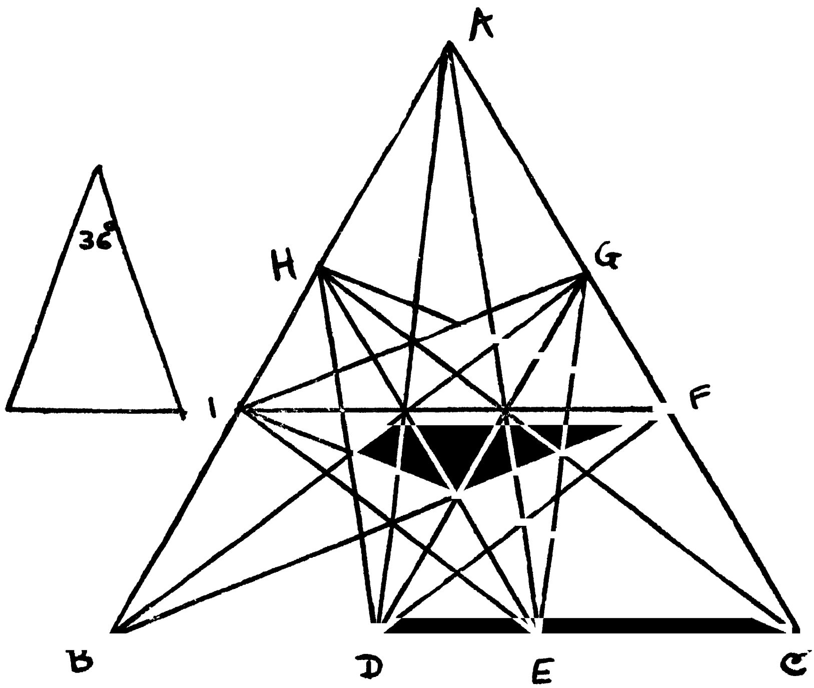
(4) P ($B_1B_3B_5B_2B_4$) This concave solid angle belongs to the great icosahedron which is bounded by 20 equilateral triangles (consider the edges in the plane P B_1B_3).

Thus we get only four concave regular polyhedra, when the symmetrical combinations of the convex solids are excluded. It is not difficult to prove that, of these four solids the great dodecahedron is the reciprocal of the small stellated dodecahedron, and the great icosahedron is the reciprocal of the great stellated dodecahedron.

It has been stated above that these concave figures can be obtained from the convex solids, by producing their faces until they meet in a point or a line; but this gives some other figures also, which are not regular but are bounded by congruent polygons. From the octahedron we get only one figure which consists of 2 intersecting tetrahedra. Three figures (1) the small stellated dodecahedron (2) the great dodecahedron and (3) the great stellated dodecahedron—can be obtained from the dodecahedron by repeated stellation, and all of these are regular. From the icosahedron it is possible to obtain 19 figures only one of which—the great icosahedron—is regular. Some of these other figures are very interesting. The figure obtained after the 2nd stellation consist of 5 intersecting octahedra; and after the 5th stellation we get 3 figures two of which consist of 5 intersecting tetrahedra and are mirror images of one another, and the third consists of 10 intersecting tetrahedra.

It is easy to construct string models of these figures by first constructing stick—or wire—models of the dodecahedron and icosahedron and then joining the proper vertices by strings which will form the edges of the concave solid.

For constructing cardboard models however it is necessary to determine all the plane angles of the figure to be constructed. This can be easily done in the case of the 3 figures obtained from the dodecahedron; but in the case of the stellated icosahedra the following method must be used. If we take any face F of the icosahedron, then the other faces when produced will meet F in st. lines forming a certain rectilineal figure, and this figure will have some more lines added to it after each stellation of the solid. Hence if α and β are two icosahedra such that β is obtained from α by a number of stellations, then the figure on a face of α will form a part of the figure on a face of β. Now the great icosahedron happens to be the last but one figure in the series of stellated icosahedra and the figure on its face is an equilateral triangle crossed by certain other st. lines shown in the accompanying figure (which is interesting by itself owing to the large number of groups of concurrent st. lines and collinear points).



BD, DE, EC are taken equal to the sides of an isosceles triangle whose base is DE and vertical angle 36^0. ABC is an equilateral triangle. BD = BI = AH = AG = CF = CE. The points are joined as shown in the figure. If the sides of the 3 triangles ABC, DFH and EGI be produced to meet one another we get the net of lines on a face of the last figure in the series. All the plane angles occurring in any stellated icosahedron, can now be obtained by identifying its bounding

polygon with a part of this figure and using the methods of Plane Trigonometry to calculate the angles.

Coloured cardboard models of all these figures, constructed by the present writer, have been placed in the Wilson College Library.

Beautiful photographs of these and several other figures will be found in a German book—'Vieleike and Vielflach' by Brückner which contains a large number of theorems, about different kinds of polygons and polyhedra, and many historical notes. For further information the reader is referred to this book, where he will also find other references.

THE CLASSIFICATION OF INTEGERS

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In dealing with number-theoretic operations, we find certain operators extensible to continuous variables, and some for which no immediate extension is to be seen from natural numbers to the continuum. Here, I consider an operator of the latter type, and show its uses in classifying the entire scheme of positive integers. This note also propounds a problem, or rather many related problems without giving explicit solutions. In some cases, a good deal has been discovered about the answers, whereas the expert technician will have no difficulty in recognizing that the rest are practically insoluble in our present state of knowledge regarding the theory of numbers.

1. For any positive integer n, we define the operator:

$\mathrm{K}[n]$ = The sum off all factors of n including unity, but excluding n itself.

Thus: $\mathrm{K}[1] = 0 \quad \mathrm{K}[2] = \mathrm{K}[3] = \mathrm{K}[p] = 1 \qquad p$ any prime.

$$\mathrm{K}[2^t] = 2^t - 1 \text{ etc.}$$

A first classification of the numbers can be effected into:

abundant numbers: $\mathrm{K}[n] > n$

deficient numbers: $\mathrm{K}[n] < n$

and the boundary class, usually included with the abundant, of the perfect numbers: $\mathrm{K}[n] = n$. The problem of the distribution, or rather the proportion of these, has been attacked with some success, with the knowledge that the deficient numbers form slightly more than a half of the total. As the multiples of any abundant or perfect number are also abundant, a more essential problem is the number of *primitive* abundant numbers, one to which Dickson has made several most brilliant contributions.

It is seen that $\mathrm{K}[n] = m$ regarded as an equation for n, given m, has not always a solution; as for example, $m = 2, 5, \ldots$. Again, the solution whenever it exists, need not be unique.

2. The operator $\mathrm{K}[n]$ may be repeated:

$\mathrm{K}[\mathrm{K}[n]] = \mathrm{K}^2[n]$ and so on.

If $\mathrm{K}^r[n] = 1$ then r is defined as the *class* of the integer n. The class of unity will be defined as zero from the outset, and it will then be the only number in its class. Whereas every integer has

another derived from it by the application of the operator K, not every integer has a class. For instance :

The perfect numbers $K[n] = n$

The amicable numbers $K[n] = m \quad K[m] = n$

We shall call numbers of this type cyclic numbers, the cycle being the least value of s for which

$$K^s \ [n] = n$$

holds true. The members of the cycle are then given by

$$K[n] \qquad K^2[n] \qquad K^3[n] \ldots\ldots K^{s-1} \ [n]$$

I do not recall having seen any discussion of numbers of cycle greater than two.

There is still a further possibility of numbers without class: the numbers of class or cycle infinity. By this is meant numbers n, if any, such that for every a, another b exists to satisfy the inequality:

$$K^a \ [n] < K^b \ [n]$$

3. The problems arising out of this classificatiou may be viewed *en bloc* :

1. What is the nature and distribution of the integers m which cannot be derived by an operation, *i.e.*, for which there is no n satisfying

$$K[n] = m$$

2. When are the solutions of the above equation unique, and what is the maximum number of solutions possible for such an equation?

3. Are there numbers in every class, and how many? For instance, primes are integers of class one, and known to be infinite in number. Here, we query whether

$$K^r \ [n] = 1$$

has any solutions for a given r and the number of these.

4. Do there exist numbers of any preassigned cycle: are there solutions for every s of

$$K^s \ [n] = n$$

and how many sets?

The questions 3 and 4 concern the existence and number of solutions of simple operational equations ; the general problem is too vague to be of interest at present.

5. Are there numbers without class or cycle?

6. Are there integers of mixed class and cycle? *i. e.*, integers which, after a certain number of operations, reduce to a cyclic number. [These can be shown to exist, as for example $K[25] = 6$, $K[6] = 6$. This also shows the non-uniqueness of the solutions of operational

equations]. Are there integers of the mixed type for every class and every possible cycle? And what is their distribution?

7. The integers being written down in their order, what is the distribution into classes and cycles? In the set

$$1, 2, 3, 4, 5, 6, \ldots\ldots\ldots, N.$$

how many classes and cycles are there represented, and what is the number of integers in each class and cycle represented, under the limit N? How many mixed integers are there under the limit?

It should be noted that this is a generalization of the classical problem regarding the distribution of primes. It may be hoped that the two supplement each other, and that some light will be thrown in the near future on the more general problem as related to the older one. As stated, this may be called the problem of the classification of integers.

THE RESISTANCE OF A SPHERE DUE TO ITS UNIFORM TRANSLATION IN A VISCOUS LIQUID

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It has been demonstrated by experimental investigations[1] and by theoretical considerations[2] as well, that Stokes's law can only give a rough value for the resistance experienced by a sphere as it moves uniformly in a viscous liquid. The main object of the present paper has been to determine an expression for the resistance which would have a larger domain of validity than Stokes's formula. It may be remarked that the formula obtained in this paper has its limitations but it is believed that the range of its applicability is larger than that of any other corrected form of Stokes's law. An attempt has also been made here to suggest an approximate form of the *complete* equations of motion, which would be valid at infinity.[3]

1. *General Transformation.*

Suppose the sphere to be moving with a uniform velocity U in a direction which we take as the axis of x. Since the motion is taken to be steady the complete equations of motion referred to a system of parallel axes moving with and through the centre of the sphere, are

$$\left.\begin{aligned} \frac{1}{\nu}\left[(u-\mathrm{U})\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}+w\frac{\partial u}{\partial z}\right]&=\frac{\mathrm{X}}{\nu}-\frac{1}{\mu}\frac{\partial p}{\partial x}+\nabla^2 u,\\ \frac{1}{\nu}\left[(u-\mathrm{U})\frac{\partial v}{\partial x}+v\frac{\partial v}{\partial y}+w\frac{\partial v}{\partial z}\right]&=\frac{\mathrm{Y}}{\nu}-\frac{1}{\mu}\frac{\partial p}{\partial y}+\nabla^2 v,\\ \text{and}\quad \frac{1}{\nu}\left[(u-\mathrm{U})\frac{\partial w}{\partial x}+v\frac{\partial w}{\partial y}+w\frac{\partial w}{\partial z}\right]&=\frac{\mathrm{Z}}{\nu}-\frac{1}{\mu}\frac{\partial p}{\partial z}+\nabla^2 w,\end{aligned}\right\}\quad \ldots \quad (1)$$

together with $$\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}+\frac{\partial w}{\partial z}=0; \qquad (2)$$

where u, v, w are the components of the velocity and p the pressure at any point in the liquid whose co-ordinates are (x, y, z) referred to

1. H. S. Allen, *Phil. Mag.*, 1900, pp. 323-338; H. D. Arnold, *Phil. Mag.*, 1911, Vol. 22.

2. C. W. Oseen, *Arkiv. f. Mat. Astro. och Fys.*, Bd. 6, 1911; H. Lamb, *Phil. Mag.*, Vol. 21, 1911; R. W. Burgess, *Amer. Jour. of Math.*, Vol. 38, 1916. Also see Lamb's *Hydrodynamics*, 5th Edition.

3. I would like to express my thanks to Dr. Ganesh Prasad and to Prof. C. W. Oseen and Dr. H. Faxen (of the University of Upsala, Sweden) for their kind and valuable criticisms and suggestions during the preparation of this work.

the moving axes, ν ($=\mu$/density) the kinematic co-efficient of viscosity, and X, Y, Z the components of extraneous forces. Since the vortex lines must be circles having the axis of x as the common axis, we may assume

$$\xi = 0,\ \eta = -\frac{\partial \chi}{\partial z},\ \zeta = \frac{\partial \chi}{\partial y}, \tag{3}$$

where χ is a function of x and ω ($=\sqrt{y^2+z^2}$) only, and

$$\xi = \frac{\partial w}{\partial y} - \frac{\partial v}{\partial z},\ \eta = \frac{\partial u}{\partial z} - \frac{\partial w}{\partial x},\ \zeta = \frac{\partial v}{\partial x} - \frac{\partial u}{\partial y}. \tag{4}$$

From (3) we get $\dfrac{\partial w}{\partial y} = \dfrac{\partial v}{\partial z}$, and so we further assume

$$v = \frac{\partial^2 f}{\partial x \partial y} \text{ and } w = \frac{\partial^2 f}{\partial x \partial z}, \tag{5}$$

f being, like χ, a function of x and ω. We then get, from the other equations of (3),

$$\frac{\partial u}{\partial z} - \frac{\partial^3 f}{\partial x^2 \partial z} = -\frac{\partial \chi}{\partial z}$$

and
$$\frac{\partial u}{\partial y} - \frac{\partial^3 f}{\partial x^2 \partial y} = -\frac{\partial \chi}{\partial y},$$

which are obviously satisfied by

$$u = \frac{\partial^2 f}{\partial x^2} - \chi. \tag{6}$$

The equation (2) then gives

$$-\frac{\partial \chi}{\partial x} + \frac{\partial^3 f}{\partial x^3} + \frac{\partial^3 f}{\partial x \partial y^2} + \frac{\partial^3 f}{\partial x \partial z^2} = 0;$$

whence we have
$$\chi = \nabla^2 f. \tag{7}$$

Thus u, v, w are expressed in terms of a single function f which contains as we know, x and ω only. This may be further simplified by assuming that f is a function of x and ρ ($=\sqrt{x^2+\omega^2}$). It may be noticed that this function is tacitly taken to be continuous and its derivatives, upto a certain order, to be existent.

If the extraneous forces have a potential, we can obtain from (1), by cross-differentiation, the following.

$$\frac{1}{\nu}\left[(u-U)\frac{\partial}{\partial x} + v\frac{\partial}{\partial y} + w\frac{\partial}{\partial z} - \frac{v}{y}\right]\frac{\partial \chi}{\partial y} = \nabla^2\left(\frac{\partial \chi}{\partial y}\right). \tag{8}$$

This then is the equation from which the function f is to be determined.

2. *Objections to the Previous Results.*

Stokes's results could be obtained from (8) if the left-hand side be neglected altogether; that is, if we take

$$\nabla^2\left(\frac{\partial \chi}{\partial y}\right) = 0 \text{ or } \nabla^2 \chi = 0, \tag{9}$$

instead of (8), as our fundamental equation. The solution of $\frac{\partial \chi}{\partial y}=0$ is neglected for obvious reasons. The simplest solution of (9), compatible with the condition of rest at infinity, is

$$\chi = \frac{c}{\rho} \quad \text{or} \quad \nabla^2 f = \frac{c}{\rho}.$$

Taking f to be a function of ρ, we get

$$\rho^2 \frac{d^2 f}{d\rho^2} + 2\rho \frac{df}{d\rho} = c\rho,$$

whence

$$f = \frac{d}{\rho} + \tfrac{1}{2} c\rho;$$

leading to

$$\left.\begin{aligned} u &= -\frac{c}{2\rho} - \frac{d}{\rho^3} + \left(\frac{d}{\rho^5} - \frac{c}{2\rho^3}\right)x^2, \\ v &= \left(\frac{d}{\rho^5} - \frac{c}{2\rho^3}\right) xy \text{ and } w = \left(\frac{d}{\rho^5} - \frac{c}{2\rho^3}\right) xz. \end{aligned}\right\} \qquad (10)$$

The condition of non-slipping at the surface of the sphere ($\rho = a$) requires that

$$c = -\tfrac{3}{2} Ua, \quad d = -\tfrac{1}{4} Ua^3. \qquad (11)$$

Prof. Oseen[1] has shown that although this solution of Stokes holds for points near the sphere, it is not valid at points at great distance from the latter. The reason advanced by him is that the ratio of the hypothetical constraining forces to the viscous forces is of the order $U\rho/\nu$ which becomes infinite with ρ; hence it would not be justifiable to omit altogether the terms on the left-hand sides of the equations of motion for the region far removed from the sphere. The modified solution given by him satisfies the equation (8) when all the terms on the left-hand side, excepting the one involving U, are omitted.

This modified equation, which we may name (8 A), can also be obtained from the following considerations.[2] Consider the term $(u-U)\frac{\partial u}{\partial x}$; at points very near the sphere $(u-U)$ is quite small and hence the neglect of this term may be justified here. But at distant points $(u-U)$ is not small; in fact, it tends to $-U$ as we recede farther and farther from the sphere. Therefore for the region far removed from the sphere the equation can take the approximate form (8 A).

Now as the value of u ranges from U to zero, it is obvious that there are points at which $(u-U)$ neither assumes a value negligibly small nor a value which differs from $-U$ by a very small quantity;

1. Loc. cit.
2. Cf. Burgess and Oseen, loc. cit.

its value at these points can rather be denoted by $-U\lambda$, where λ is a proper fraction, and the equations of motion have here to be suitably modified. The form (8A) does not hold here.

Again, the equation (8A) can be obtained from (1) by omitting terms $u\frac{\partial u}{\partial x}, \ldots\ldots$ from the left-hand sides. As u has values ranging from U to zero, it would not be reasonable to take terms like $-U\frac{\partial u}{\partial x}$ into account whilst neglecting terms of the same order of magnitude (for some points at least), *viz.* $u\frac{\partial u}{\partial x}$, etc.

Thus we see that while the equations Stokes started from are true for points very near the sphere and those considered by Prof. Oseen (and also by Prof. Lamb) for points far from the sphere, no provision has been made for the intermediate region. Prof. Lamb has, however, shown that the latter results can, to a first approximation, be applicable to this region also. In order to include this domain into our considerations we must take the *complete* equations of motion.

3. *Consideration of the complete equations of motion.*

We have seen that the complete equations of motion (1) can be reduced to a single equation (8) involving only one unknown function f. This equation cannot, however, be solved completely, but it is possible to obtain approximate solutions by a process of successive approximation. We shall put $k = U/2\nu$, as has been done by Prof. Lamb.

As f_0, where $\nabla^2 f_0 = 0$, also furnishes a solution for f we can put

$$u = u_0 + u',\ v = v_0 + v' \text{ and } w = w_0 + w' \tag{12}$$

for our complete solution, u_0, v_0, w_0 being derivable from f_0. The condition of rest at infinity requires that

$$\left.\begin{aligned} u_0 &= c_0\frac{\partial}{\partial x}\left(\frac{1}{\rho}\right) + c_1\frac{\partial^2}{\partial x^2}\left(\frac{1}{\rho}\right) + \ldots\ldots\ldots \\ v_0 &= c_0\frac{\partial}{\partial y}\left(\frac{1}{\rho}\right) + c_1\frac{\partial^2}{\partial x \partial y}\left(\frac{1}{\rho}\right) + \ldots\ldots\ldots \\ w_0 &= c_0\frac{\partial}{\partial z}\left(\frac{1}{\rho}\right) + c_1\frac{\partial^2}{\partial x \partial z}\left(\frac{1}{\rho}\right) + \ldots\ldots\ldots \end{aligned}\right\} \tag{13}$$

We propose now to obtain approximate solutions of (8) in the case of slow motion, that is, when ka is a small quantity. For a first approximation we shall neglect all terms involving second and higher powers of ka. We assume that $f = f_1 + f_2$,

$$\left.\begin{aligned} \text{where} \quad f_1 &= e^{-k\rho}\left[A_0(1+k\rho) + A_1 x\right] \\ \text{and} \quad f_2 &= e^{-2k\rho}\left[B_0 + B_1 x\right], \end{aligned}\right\} \tag{14}$$

the A's and the B's being functions of ρ and the B's being dependent on the A's satisfies the equation (8) to the first approximation. For the sake of convenience we shall denote by u_1, v_1, w_1, χ_1, the values of u, v, w, χ, derived from f_1 and similarly for others. Also, by D_n the operator

$$\frac{1}{\nu}\left[u_n \frac{\partial}{\partial x} + v_n \left(\frac{\partial}{\partial y} - \frac{1}{y} \right) + w_n \frac{\partial}{\partial z} \right] \frac{\partial}{\partial y}.$$

We do not purposely take into account such values of f (except f_0) which do not possess $e^{-k\rho}$ as factor, since it can easily be shown that they furnish velocity-components which are incompatible with the condition of rest at infinity. For the same reason we take it that the unknown functions of ρ, *viz.* A_0, etc., do not contain any exponential factor; in other words we shall treat them as polynomials only.

The form of Stokes's solution leads us to assume further that only c_1 and the function A_0 include terms free from k. The values of these functions can be derived from the equations we would obtain by equating the co-efficients of $e^{-k\rho}$ and $e^{-2k\rho}$ from the two sides of the equation (8) when the presumed solutions are put in. Substituting (12) and (14) in (8) we thus get to this approximation

$$\left(\nabla^2 + 2k \frac{\partial}{\partial x} \right) \frac{\partial \chi_1}{\partial y} = D_0 \chi_1 , \quad \ldots \quad \ldots \quad (15)$$

and

$$\left(\nabla^2 + 2k \frac{\partial}{\partial x} \right) \frac{\partial \chi_2}{\partial y} = D_0 \chi_2 + D_1 \chi_1 . \quad (16)$$

The equation (15) will hold if

$$F_0'' A_0 = 0 ; \quad \ldots \quad \ldots \quad \ldots \quad (17)$$

$$F_1'' A_1 = \left(-2k + \frac{2c_1}{\nu \rho^3} \right) F_0' A_0 ; \quad (18)$$

where

$$\left.\begin{aligned} F_n'' &\equiv \frac{d^5}{d\rho^5} + \frac{4(n+1)}{\rho} \frac{d^4}{d\rho^4} + \frac{4(n^2-1)}{\rho^2} \frac{d^3}{d\rho^3} - \frac{12n(n+1)}{\rho^3} \frac{d^2}{d\rho^2} \\ &\qquad + \frac{12n(n+1)}{\rho^4} \frac{d}{d\rho}. \\ \text{and} \quad F_n' &\equiv \frac{1}{\rho} \frac{d^4}{d\rho^4} + \frac{2n+1}{\rho^2} \frac{d^3}{d\rho^3} - \frac{6(n+1)}{\rho^3} \frac{d^2}{d\rho^2} + \frac{6(n+1)}{\rho^4} \frac{d}{d\rho}. \end{aligned}\right\} (19)$$

These equations are satisfied by

$$A_0 = \frac{a_1}{\rho} + a_2 \rho , \quad \ldots \quad \ldots \quad \ldots \quad (20)$$

and

$$A_1 = \frac{a_3}{\rho} + \frac{a_4}{\rho^3} - \tfrac{1}{2} a_2 k \rho + \frac{a_2 c_1}{4 \nu \rho^2} , \quad \ldots \quad (21)$$

the a's being constants. The equation (16) then gives

$$F_0'' B_0 = 0 \quad \ldots \quad \ldots \quad \ldots \quad (22)$$

and
$$\rho^5 F_1'' B_1 = \frac{12a_2}{\nu}\left(\frac{a_1}{\rho^2} - a_2\right); \quad . . \quad (23)$$

whence $B_0 = 0$ and $B_1 = \frac{a_2}{4\nu}\left\{\frac{a_1}{\rho^2} - 2a_2 \log(k\rho)\right\}$ . . . . (24)

From the condition of non-slipping at the surface of the sphere we next obtain

$$c_0 = 0,\ a_1 + c_1 = -\tfrac{1}{4}Ua^3,\ a^2 = -\tfrac{3}{4}\,Ua.$$
$$a_3 = -\frac{3}{16}\,Uka^3,\ a_4 - c_2 = -\frac{1}{16}\,Uka_5.$$

Thus we see that we can safely put $c_0 = c_1 = c_2 = 0$. Hence the subsequent values of the constants, *viz.*

$$a_1 = -\tfrac{1}{4}Ua_3,\ a_2 = -\tfrac{3}{4}\,Ua,\ a_3 = -\frac{3}{16}\,Uka^3,\ a_4 = -\frac{1}{16}\,Uka^5, \quad (25)$$

lead to

$$u = e^{-k\rho}\Big[(1+k\rho)\left\{\left(\tfrac{3}{4}\frac{Ua}{\rho} + \tfrac{1}{4}\frac{Ua^3}{\rho^3}\right) + x^2\left(\tfrac{3}{4}\frac{Ua}{\rho^3} - \tfrac{3}{4}\frac{Ua^3}{\rho^5}\right)\right\}$$
$$+ \tfrac{3}{8}\frac{Ukax}{\rho}\left(-1 + \frac{a^2}{2\rho^2} + \frac{3a^4}{2\rho^4}\right) - \tfrac{3}{8}\frac{Ukax^3}{\rho^3}\left(1 + \frac{5a^2}{2\rho^2} + \frac{3a^4}{2\rho^4}\right)\Big]$$
$$+ e^{-2k\rho}\left[-\tfrac{3}{8}\frac{Uka^4x}{\rho^4} + \tfrac{3}{8}\left(3 + \frac{2a^2}{\rho^2}\right)\frac{Uka^2x^3}{\rho^4}\right], \quad (26)$$

$$v = e^{-k\rho}\Big[(1+k\rho)\left(\tfrac{3}{4}\frac{Ua}{\rho^3} - \tfrac{3}{4}\frac{Ua^3}{\rho^5}\right)xy + \tfrac{3}{8}\frac{Ukay}{\rho}\left(1 + \frac{a^2}{2\rho^2} + \frac{a^4}{2\rho^4}\right)$$
$$-\tfrac{3}{8}\frac{Ukax^2y}{\rho^3}\left(1 + \frac{5a^2}{2\rho^2} + \frac{3a^4}{2\rho^4}\right)\Big]$$
$$+ e^{-2k\rho}\left[-\frac{9}{16}\left(1 + \frac{a^2}{3\rho^2}\right)\frac{Uka^2y}{\rho^2} + \tfrac{3}{8}\left(3 + \frac{2a^2}{\rho^2}\right)\frac{Uka^2x^2y}{\rho^4}\right], \quad (27)$$

and similarly for w.

4. *The second approximation.*

We next carry the calculations to the second degree of approximation by retaining terms involving the second power of ka. We begin by assuming our solution to be

$$f = f_1 + f_2 + f_3 \quad . . . . \quad (28)$$

where $f_1 = e^{-k\rho}\left[\left(\frac{a_1}{\rho} + a_2\rho\right) + \left(\frac{a_3}{\rho} + \frac{a_4}{\rho^3} - \tfrac{1}{2}a_2k\rho\right)x + A_0 + A_1x + A_2x^2\right]$, (29)

$$f_2 = e^{-2k\rho}\left[\left\{\frac{a_1}{\rho^2} - 2a_2\log(k\rho)\right\}\frac{a_2x}{4\nu} + B_0 + B_1x + B_2x^2\right] \quad . . . . \quad (30)$$

and $f_3 = e^{-3k\rho}\left[C_0 + C_1x + C_2x^2\right]$ . . . . (31)

the A's, the B's and the C's all having k^2 as factor. As before, we take it that the values of the functions B and C depend on those of A's. Following the procedure of the last article we get

$$\left.\begin{aligned} A_0 &= \frac{b_1}{\rho} + b_2\rho + b_3\rho^2 - \frac{b_8}{3\rho^3} - \frac{5}{12}Uk^2a\,\rho^3 ; \\ A_1 &= \frac{b_4}{\rho} + \frac{b_5}{\rho^3} + b_6\,\rho^2 - \frac{1}{16}\frac{Uk^2a^5}{\rho^2} ; \\ A_2 &= \frac{b_7}{\rho^3} + \frac{b_8}{\rho^5} - \tfrac{1}{8}Uk^2a\rho + \frac{3}{32}Uk^2a^3. \end{aligned}\right\} \quad \ldots (32)$$

also
$$\left.\begin{aligned} B_0 &= Uk^2a^2 \left[\frac{9}{40}\rho^2 \log k\rho - \frac{3}{64}a^2 \log k\rho + \frac{3}{256}\frac{a^4}{\rho^2}\right] ; \\ B_1 &= Uk^2a^2 \left[-\frac{9}{8}\rho \log k\rho \right] ; \\ B_2 &= Uk^2a^2 \left[\frac{129}{320}\log k\rho - \frac{3}{16}\frac{a^2}{\rho^2} + \frac{3}{512}\frac{a^4}{\rho^4}\right] . \end{aligned}\right\} \quad (33)$$

and
$$\left.\begin{aligned} C_0 &= Uk^2a^2 \left[\left(\frac{9}{140}\frac{a^3}{\rho} - \frac{1}{560}\frac{a^5}{\rho^3}\right)\log k\rho - \frac{1}{672}\frac{a^5}{\rho^3}\right] ; \\ C_1 &= 0 ; C_2 = Uk^2a^2\left[\frac{27}{64}\frac{a}{\rho} + \left(\frac{3}{70}\frac{a^3}{\rho^3} + \frac{3}{560}\frac{a^5}{\rho^5}\right)\log k\rho\right] . \end{aligned}\right\} (34)$$

The values of the constants satisfying the boundary condition at the surface of the sphere can now be easily found to be

$$\begin{aligned} b_1 &= -\frac{6903}{44800}Uk^2a^5 - \frac{81}{280}Uk^2a^5 \log ka ; \\ b_2 &= -\frac{431}{3200}Uk^2a^3 - \frac{27}{40}Uk^2a^3 \log ka ; \\ b_3 &= 0 ; b_4 = -\frac{27}{16}Uk^2a^5 ; \; b_5 = \frac{3}{8}Uk^2a^6 ; \; b_6 = 0 ; \\ b_7 &= \frac{351}{8960}Uk^2a^5 - \frac{3}{70}Uk^2a^5 \log ka ; \\ b_8 &= \frac{401}{44800}Uk^2a^7 - \frac{3}{560}Uk^2a^7 \log ka . \qquad \ldots \quad \ldots (35) \end{aligned}$$

It may be noted that the values of $u, v, w,$ thus calculated contain certain terms involving log $(k\rho)$ as factor. This makes the corresponding terms assume the indeterminate form $0 \times \infty$ when ρ is infinite; this does not, however, impair the condition of rest at infinity since the ultimate limit of each of these terms is zero.

Using the values obtained above we find that, in the absence of extraneous forces, the resistance experienced by the sphere is parallel to the x – axis and is given by

$$R = -6\pi\mu\, Ua \left[1 + \left\{\frac{887}{800} + \frac{9}{10}\log ka\right\} k^2a^2\right] \quad (36)$$

Thus (36) represents what Stokes's law should be upto this approximation.

The method indicated above can be employed with success to obtain better results, that is, upto higher degrees of approximation.

5. *Comparison with experimental observations.*

In order to find within what limits the formula (36) is applicable I have used the results given by Arnold (loc. cit.) in Table II of his paper. Arnold's experiments, however, were carried on with small spheres falling in a liquid contained in a long vertical tube. In deriving the formula (36), on the other hand, we had assumed that the liquid was infinite in extent. In Arnold's experiment the condition of infiniteness is to a certain extent maintained on account of the relatively large size of the cross-section of the fall-tube (in comparison with the radius of the falling sphere) used by him; but the liquid in the tube cannot, in the strict sense, be regarded as infinite. It has been shown by Faxén that the effect of the presence of the walls of the tube is to increase the resistance by a factor whose value depends on kr, where r is the radius of the cross-section of the tube, when k is small enough. The resistance calculated from the formula (36) derived in this paper should, in these cases, be less than the actual resistance experienced by the sphere.

Now if a sphere of radius a and of material whose density is σ be falling in a liquid of density d under the action of gravity, the force which accelerates its motion is given by

$$\frac{4\pi a^3}{3}(\sigma-d)\,g\,. \qquad \ldots \quad \ldots \quad \ldots \quad (37)$$

In the case of steady motion this force will be just balanced by the resistance of the sphere due to the liquid. Thus we get a criterion for testing the degree of accuracy of the various formulas. I shall also be giving, in the succeeding Table, values computed from the formula of Prof. Oseen, viz.

$$R = -6\pi\mu U a\left(1+\tfrac{3}{8}ka\right) \ldots \quad \ldots \quad \ldots \quad \ldots (38)$$

Again, since the formulas (36) and (38) refer to the terminal velocity and since in the following computations the values of U used are taken from the experimental observations which are never greater than the terminal velocities, it should be expected that the values calculated from these formulas would be less than those derived from the formula (37).

The validity of the formula (36) is apparent from the Table if we consider that it gives values sufficiently less than those obtained from (37). Prof. Oseen's formula appears to give more approximate results than (36), even when a is as large as ·0704; for this case ka is sufficiently large and such agreement leaves a doubt in one's mind as to the validity of his formula for such big values of a at least. For low values of a, however, the three formulas agree to a very close approximation.

Proceeding to the next higher approximation, I have calculated the expression for the resistance and have found that it consists of a term of the form

$$-6\pi\mu Ua\,[\alpha+\beta \log ka]\,k^3a^3. \quad \ldots \quad \ldots \quad (39)$$

in addition to the expression (36). The values of α and β are 7·49 and 2·54 approximately. It has been found that this term produces no perceptible change in the values given in the Table upto $a = \cdot 0329$. For the remaining cases the increments are:

·001, ·003, ·003, ·004, ·020, ·059, ·078, ·100, ·171, ·310, ·655, ·837, ·921, ·963, 1·195, 1·751, 2·223, 4·087, 5·067

respectively. It may be noticed that, for the last two cases only, this causes the value of the resistance to exceed that in the third column. This discrepancy is, I think, due to the fact that the radii of the spheres in these cases are too great for this approximation, and would disappear if terms of higher orders are brought in.

a	ka	Resistance calculated from		
		Formula (37)	Formula (36)	Formula (38)
·00651	·0005	·00998	·00972	·00972
·00912	·00132	·0274	·0263	·0263
·0102	·0018	·0384	·0365	·0366
·0104	·00194	·0401	·0387	·0388
·0190	·0114	·248	·227	·229
·0200	·0135	·289	·268	·271
·0208	·0156	·325	·310	·313
·0252	·0257	·579	·511	·521
·0301	·0438	·986	·868	·899
·0310	·0476	1·078	·944	·982
·0329	·0567	1·288	1·123	1·177
·0372	·0798	1·862	1·576	1·683
·0400	·0991	2·315	1·954	2·119
·0403	·101	2·367	1·996	2·168
·0408	·106	2·456	2·079	2·267
·0462	·143	3·567	2·814	3·141
·0497	·177	4·440	3·466	3·981
·0510	·187	4·798	3·668	4·241
·0515	·197	4·940	3·866	4·498
·0538	·220	5·632	4·326	5·103
·0562	·2503	6·420	4·938	5·916
·0594	·294	7·580	5·862	7·151
·0609	·3105	8·169	6·213	7·619
·0613	·317	8·319	6·360	7·813
·0619	·320	8·579	6·429	7·905
·0630	·336	9·044	6·780	8·367
·0644	·365	9·660	7·470	9·266
·0688	·385	10·781	7·953	9·883
·0690	·441	11·883	9·605	11·692
·0704	·467	12·620	10·161	12·560

It may be added here that the radius of the fall-tube was ·547, so that one may compare this to the radius of the falling sphere.

ON THE SET OF POINTS $\dfrac{\Phi(n)}{n^2}$

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I. Let $\Phi(n)$ denote the number of "Unkurzbar" fractions $\left(\text{the fraction } \dfrac{a+ib}{n}, \quad \begin{matrix} 1 \leqslant a \leqslant n \\ 1 \leqslant b \leqslant n \end{matrix} \quad \text{is called "kurzbar" if } (a, b, n) > 1, \text{ "unkurzbar" if } (a, b, n) = 1\right)$

It is known that

$$\Phi(n) = n^2\left(1-\frac{1}{p^2}\right)\left(1-\frac{1}{q^2}\right)\left(1-\frac{1}{r^2}\right) \ldots\ldots$$

if $n = p^\alpha q^\beta r^\gamma \ldots\ldots$ where $p, q, r \ldots\ldots$ are different primes.

It follows that if $f(n) = \dfrac{\Phi(n)}{n^2}$ then $0 < f(n) < 1$

We propose to prove :—

*Th. (1). Every point of the interval $\left(\dfrac{6}{\pi^2}, 1\right)$ is a limiting point of the set of points $f(n)$.

(a) Let p_r be the rth prime then

$$f(p_r) = \frac{\Phi(p_r)}{p_r^2} = \left\{1-\frac{1}{p_r^2}\right\} \to 1 \qquad \text{as } r \to \infty$$

$\therefore$ 1 is a Limiting point of the set of points $f(n)$.

(b) Let $n_r = p_1 p_2 \ldots\ldots p_r$. Then

$$f(n_r) = \left\{1-\frac{1}{p_1^2}\right\}\left\{1-\frac{1}{p_2^2}\right\} \ldots\ldots \left\{1-\frac{1}{p_r^2}\right\}$$

This product tends to $\dfrac{1}{\zeta(2)} = \dfrac{6}{\pi^2}$ as $r \to \infty$,

Where $\zeta(s)$ denotes the Zeta Function of Riemann.

$\therefore \quad \dfrac{6}{\pi^2}$ is a limiting point of the set.

(c) Let $\dfrac{6}{\pi^2} < p < 1 \qquad\qquad 0 < \varepsilon < p - \dfrac{6}{\pi^2}$

* For a similar method applied in a different problem, see a paper by Dr. T. Vijayaraghvan, I. M. S. Journal, Vol. XII, p. 98,

We prove that a number N exists such that $p - \varepsilon < f(N) < p$ (1)
from which it will follow that p is a limiting point of the set $f(n)$.

Choose a prime number P_1 so large that

$$P_1^2 > \frac{1}{1-p} \qquad P_1^2 > \frac{p}{\varepsilon} \quad \ldots \quad (2)$$

Let $P_2, P_3, \ldots$ be the prime numbers in order following P_1.
Consider numbers $N_1, N_2, \ldots$ defined by

$$N_m = P_1 P_2 \ldots P_m \qquad (m = 1, 2, \ldots)$$

$$\text{Then } f(N_m) = \left(1 - \frac{1}{P_1^2}\right)\left(1 - \frac{1}{P_2^2}\right)\ldots\left(1 - \frac{1}{P_m^2}\right)$$

Also $f(N_1), f(N_2) \ldots$ form a decreasing sequence.

Further $f(N_1) = 1 - \frac{1}{P_1^2} > 1 - (1-p) = p$ from (2).

$\therefore$ If none of the numbers $N_2, N_3, \ldots$ satisfy inequalities (1), there should exist an integer $k \geqslant 1$ so that

$$f(N^k) \geqslant p \quad \ldots \quad f(N_{k+1}) \leqslant p - \varepsilon$$

In this case we have

$$\left(1 - \frac{1}{P_1^2}\right) \ldots \left(1 - \frac{1}{P_k^2}\right) \geqslant p$$

$$\left(1 - \frac{1}{P_1^2}\right) \ldots \left(1 - \frac{1}{P_{k+1}^2}\right) \leqslant p - \varepsilon$$

$$\therefore 1 - \frac{1}{P_{k+1}^2} \leqslant \frac{p-\varepsilon}{p}$$

$$\therefore P_{k+1}^2 \leqslant \frac{p}{\varepsilon}$$

But $P_{k+1} > P_1$ $\qquad \therefore P_1^2 < \frac{p}{\varepsilon}$

which contradicts second of inequalities (2). Hence a number N exists which satisfies (1) and the theorem is therefore proved.

2. Let $\Psi(n)$ = number of "kurzbar" fractions

$$\text{Then } \Psi(n) = n^2 - n^2\left(1 - \frac{1}{p^2}\right)\left(1 - \frac{1}{q^2}\right) \ldots$$

$$\therefore \frac{\Psi(n)}{n^2} = 1 - \left(1 - \frac{1}{p^2}\right)\left(1 - \frac{1}{q^2}\right) \ldots$$

$$\therefore \overline{\lim_{n\to\infty}} \frac{\Psi(n)}{n^2} = 1 - \frac{6}{\pi^2}$$

$$\underline{\lim_{n\to\infty}} \frac{\Psi(n)}{n^2} = 0$$

and by Th. (1) we get the result that every point of the interval $\left(0, 1 - \frac{6}{\pi^2}\right)$ is a limiting point of the set of points $\frac{\Psi(n)}{n^2}$.

3. Let $a_n = \frac{\Phi(n)}{n^2}$

Then $\sum_{n=1}^{\infty} \frac{a_n}{n^s} = F(s)$ is convergent for $\sigma > 1$ where $s = \sigma + it$.

Hence by a well-known Theorem (Landau Primzahlen Vol. I Page 115) we get

$$\overline{\lim_{s=1}} (s-1) f(s) \leqslant \overline{\lim_{N=\infty}} \frac{\sum_{n=1}^{N} a_n}{N}$$

$$\underline{\lim_{s=}} (s-1) f(s) \geqslant \underline{\lim_{N=\infty}} \frac{\sum_{n=1}^{N} a_n}{N}$$

Now $\sum_{n=1}^{\infty} \frac{a_n}{n^s} = \frac{\zeta(s)}{\zeta(s+2)}$

and $\lim_{s=1} (s-1) \frac{\zeta(s)}{\zeta(s+2)} = \frac{1}{\zeta(3)}$

$\therefore$ We have $\underline{\text{Lim}}_{N=\infty} \frac{\sum_{n=1}^{N} \frac{\Phi(n)}{n^2}}{N} \leqslant \frac{1}{\zeta(3)}$.

$$\overline{\text{Lim}}_{n=\infty} \frac{\sum_{n=1}^{N} \frac{\Phi(n)}{n^2}}{N} \geqslant \frac{1}{\zeta(3)}.$$

We prove, below, that

$$\text{Lim}_{N=\infty} \frac{\sum_{n=1}^{N} \frac{\Phi(n)}{n^2}}{N} = \frac{1}{\zeta(3)}$$

4. Let α be any real number.

Th. (2)

(*a*) $\sum_{n=1}^{N} \frac{\Phi(n)}{n^\alpha} = 0(1)$ if $\alpha > 3$

(*b*) $\sum_{n=1}^{N} \frac{\Phi(n)}{n^\alpha} = \frac{\log N}{\zeta(3)} + 0(1)$ if $\alpha = 3$

(*c*) $\sum_{n=1}^{N} \frac{\Phi(n)}{n^\alpha} = \frac{N^{3-\alpha}}{(3-\alpha)\zeta(3)} + o\left(N^{3-\alpha}\right)$ if $\alpha < 3$

Proof

(*a*) $\alpha > 3$

$$\sum_{n=1}^{N} \frac{\Phi(n)}{n^\alpha} < \sum_{n=1}^{N} \frac{1}{n^{\alpha-2}} < \sum_{n=1}^{\infty} \frac{1}{n^{\alpha-2}} = 0(1)$$

(b) $\alpha = 3$,

We have $\sum_{d/n} \Phi(d) = n^2$

$$\therefore \Phi(n) = \sum_{d/n} \mu(d) \frac{n^2}{d^2} = n^2 \sum_{d/n} \frac{\mu(d)}{d^2}$$

$$\therefore \sum_{n=1}^{N} \frac{\Phi(n)}{n^\alpha} = \sum_{n=1}^{N} n^{2-\alpha} \sum_{d/n} \frac{\mu(d)}{d^2}$$

$$= \sum_{d_m \leqslant N} m^{2-\alpha} \frac{\mu(d)}{d^\alpha}$$

$$= \sum_{d=1}^{N} \frac{\mu(d)}{d^\alpha} \sum_{m=1}^{\left[\frac{N}{d}\right]} m^{2-\alpha} \qquad (3)$$

Now $1^p + 2^p + \ldots . + n^p = \dfrac{n^{p+1}}{p+1} + o\left(n^{p+1}\right)$ if $p > -1$

$= \log n + 0(1) \quad .. \quad$ if $p = -1$

$$\therefore \sum_{m=1}^{\left[\frac{N}{d}\right]} m^{2-\alpha} = \log\left[\frac{N}{d}\right] + 0(1)$$

$$= \left\{ \log N - \log d + 0(1) \right\}$$

$$\therefore \sum_{n=1}^{N} \frac{\Phi(n)}{n^\alpha} = \sum_{d=1}^{N} \frac{\mu(d)}{d^3} \left\{ \log N - \log d + 0(1) \right\}$$

$$= \log N \sum_{d=1}^{N} \frac{\mu(d)}{d^3} - \sum_{d=1}^{N} \frac{\mu(d) \log d}{d^3} + 0\left(\sum_{d=1}^{N} \frac{\mu(d)}{d^3} \right)$$

$$= \log N \sum_{d=1}^{\infty} \frac{\mu(d)}{d^3} - \log N \sum_{N+1}^{\infty} \frac{\mu(d)}{d^3} + 0(1)$$

since $\Sigma \dfrac{\mu(d) \log d}{d^3}$ and $\Sigma \dfrac{\mu(d)}{d^3}$ are both convergent.

$$\therefore \sum_{n=1}^{N} \frac{\Phi(n)}{n^\alpha} = \frac{\log N}{\zeta(3)} + 0\left(\frac{\log N}{N^2}\right) + 0(1)$$

$$= \frac{\log N}{\zeta(3)} + 0(1)$$

(c) $\alpha < 3$

We have from (3)

$$\sum_{n=1}^{N} \frac{\Phi(n)}{n^\alpha} = \sum_{d=1}^{N} \frac{\mu(d)}{d^\alpha} \sum_{m=1}^{\left[\frac{N}{d}\right]} m^{2-\alpha}$$

Where $\sum_{m=1}^{\left[\frac{N}{d}\right]} m^{2-\alpha} = \frac{1}{3-\alpha}\left[\frac{N}{d}\right]^{3-\alpha} + o\left(\frac{N^{3-\alpha}}{d^{3-\alpha}}\right)$

$$= \frac{1}{3-\alpha}\left(\frac{N}{d}\right)^{3-\alpha} + o\left(\frac{N^{3-\alpha}}{d^{3-\alpha}}\right)$$

$$\therefore \sum_{n=1}^{N} \frac{\Phi(n)}{n^{\alpha}} = \sum_{d=1}^{N}\left\{\frac{1}{3-\alpha}\,\frac{N^{3-\alpha}}{d^{3-\alpha}}\,\frac{\mu(d)}{d^{\alpha}}\right\} + o\left(N^{3-\alpha}\sum_{d=1}^{N}\frac{1}{d^{3}}\right)$$

$$= \frac{N^{3-\alpha}}{(3-\alpha)} \sum_{d=1}^{N} \frac{\mu(d)}{d^{3}} + o\left(N^{3-\alpha}\right)$$

$$= \frac{N^{3-\alpha}}{(3-\alpha)}\,\frac{1}{\zeta(3)} + o\left(N^{3-\alpha}\right)$$

5. We have $\Psi(n) + \Phi(n) = n^2$

$$\therefore \sum_{n=1}^{N}\frac{\Psi(n)}{n^{\alpha}} + \sum_{n=1}^{N}\frac{\Phi(n)}{n^{\alpha}} = \sum_{n=1}^{N} n^{2-\alpha}$$

$\therefore$ We get from Th. (2)

$$\sum_{n=1}^{N}\frac{\Psi(n)}{n^{\alpha}} = 0(1) \qquad \text{if } \alpha > 3$$

$$\sum_{n=1}^{N}\frac{\Psi(n)}{n^{\alpha}} = \log N\left\{1-\frac{1}{\zeta(3)}\right\} + 0(1) \qquad \text{if } \alpha = 3$$

$$\sum_{n=1}^{N}\frac{\Psi(n)}{n^{\alpha}} = \frac{N^{3-\alpha}}{3-\alpha}\left\{1-\frac{1}{\zeta(3)}\right\} + o\left(N^{3-\alpha}\right)$$

if $\alpha < 3$.

6. We note that for every n $\quad \Phi(n) > \Psi(n)$

For $\frac{\Phi(n)}{n^2} = \left(1-\frac{1}{p^2}\right)\left(1-\frac{1}{q^2}\right)\ldots\ldots$ if $n = p^{\alpha} q^{\beta}\ldots$

And $\frac{\Psi(n)}{n^2} = 1-\left(1-\frac{1}{p^2}\right)\left(1-\frac{1}{q^2}\right)\ldots\ldots$

Now $\left(1-\frac{1}{p^2}\right)\left(1-\frac{1}{q^2}\right)\ldots\ldots \geqslant \frac{1}{\zeta(2)}$ for every n

$$= \frac{6}{\pi^2} > \tfrac{1}{2}$$

$$\therefore n^2\left(1-\frac{1}{p^2}\right)\left(1-\frac{1}{q^2}\right)\ldots\ldots$$

$$> n^2 - n^2\left(1-\frac{1}{p^2}\right)\left(1-\frac{1}{q^2}\right)\ldots$$

$$\therefore \Phi(n) > \Psi(n)$$

*ON AN ASYMPTOTIC FORMULAE IN THEORY OF NUMBERS

By

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Let $\pi_2(x)$ denote the number of numbers less than x and which are products of two different primes. Landau has proved in his "Handbuch Der Lehre von der verteilung der Primzahlen" (Page 208) that

$$\pi_2(x) \sim \frac{x \log \log x}{\log x}$$

I propose to prove that

$$\pi_2(x) = \frac{x \log \log x}{\log x} + \frac{B\,x}{\log x} + o\left(\frac{x}{\log x}\right)$$

where B is a constant

$$= \lim_{x=\infty} \left\{ \sum_{p \leqslant x} \frac{1}{p} - \log \log x \right\}$$

Lemma 1.

$$\sum_{p<\sqrt{x}} \pi(p) \sim \frac{2x}{\log^2 x}$$

Proof

(a) If $\sqrt{x}$ is a prime, let $p_n = \sqrt{x}$ where p_n denotes n^{th} prime

Then
$$\sum_{p<\sqrt{x}} \pi(p) = \pi(2) + \ldots\ldots + \pi(p_{n-1})$$
$$= 1 + 2 + \ldots\ldots (n-1)$$
$$= \frac{n(n-1)}{2}$$

Now $\pi(\sqrt{x}) = \pi(p_n) = n$

$$\therefore n \sim \frac{2\sqrt{x}}{\log x}$$ by prime number Theorem.

and hence the required result

* I am much indebted to Dr. T. Vijayaraghwan for valuable suggestions in preparing this paper.

(b) Let $p_n < \sqrt{x} < p_{n+1}$

Then $\sum_{p<\sqrt{x}} \pi(p) = \pi(2) + \ldots + \pi(p_n)$

$$= 1 + 2 + \ldots + n = \frac{n(n+1)}{2}$$

And since $\pi(\sqrt{x}) = \pi(p_n) = n$

$\therefore$ we get the result as before

*Lemma 2.

$$\sum_{p\leqslant\sqrt{x}} \frac{\log p}{p(\log x - \log p)} = \log 2 + o(1)$$

Proof

$$\text{Let } F(u, x) = \frac{\log u}{u(\log x - \log u)}$$

Then we have

(1) $F(u, x) \geqslant 0$ for $2 \leqslant u \leqslant \sqrt{x}$

(2) $\dfrac{F(u, x)}{\log u}$ is decreasing in the range $2 \leqslant u \leqslant \sqrt{x}$, and x constant.

for $\dfrac{F(u, x)}{\log u} = \dfrac{1}{u(\log x - \log u)}$

Let $y = y(u) = u(\log x - \log u)$

Then $\dfrac{dy}{du} = \log x - \log u - 1 > 0$

for $2 \leqslant u \leqslant \sqrt{x}$

$\therefore$ y is increasing and hence $\dfrac{F(u, x)}{\log u}$ is decreasing in range $2 \leqslant u \leqslant \sqrt{x}$

(3) $\dfrac{F(2, x)}{\log 2} = \dfrac{1}{2(\log x - \log 2)} = o(1)$

$$\text{and } I = \int_2^{\sqrt{x}} \frac{du}{u(\log x - \log u)}$$

$$= \int_{\log 2}^{\frac{1}{2}\log x} \frac{dz}{\log x - z}$$

$$= \log \frac{(\log x - \log 2)}{\frac{1}{2}\log x}$$

$$= \log 2 + \log\log x + \log\left(1 - \frac{\log 2}{\log x}\right) - \log\log x$$

$$= \log 2 + o(1)$$

* In proving this lemma, we follow closely the method of the theorem on page 203 of Handbuch.

$$\therefore \quad \frac{F(2, x)}{\log 2} = o(1) = o\left\{ \int_2^{\sqrt{x}} \frac{du}{u(\log x - \log u)} \right\} = o(1)$$

Now $I(x) = \sum_{p \leqslant x} \log p = x + x\,\varepsilon(x)$

Where $\varepsilon(x) = o(1)$

$$\sum_{p \leqslant \sqrt{x}} \frac{\log p}{p(\log x - \log p)} = \sum_{2}^{[\sqrt{x}]} \frac{I(n) - I(n-1)}{n(\log x - \log n)}$$

$$= \sum_{2}^{[\sqrt{x}]} \frac{1}{n(\log x - \log n)} + \sum_{2}^{[\sqrt{x}]} \frac{n\,\varepsilon(n) - (n-1)\,\varepsilon(n-1)}{n(\log x - \log n)}$$

$$= \sum_{2}^{[\sqrt{x}]} \frac{1}{n(\log x - \log n)} + \sum_{2}^{[\sqrt{x}]-1} n\,\varepsilon(n) \left\{ \frac{1}{n(\log x - \log n)} - \frac{1}{(n+1)(\log x - \overline{n+1})} \right\}$$

$$+ \frac{1}{2(\log x - \log 2)} + [\sqrt{x}]\,\varepsilon\left([\sqrt{x}]\right) \frac{1}{[\sqrt{x}](\log u - \log [\sqrt{x}])}$$

Now by (1), (2) and (3)

$$\sum_{n=2}^{[\sqrt{x}]} \frac{1}{n(\log x - \log n)} + \frac{1}{2(\log x - \log 2)}$$

$$= \int_2^{\sqrt{x}} \frac{du}{u(\log x - \log u)} + o\left\{ \int_2^{\sqrt{x}} \frac{du}{u(\log x - \log u)} \right\}$$

$$= \log 2 + o(1)$$

Further for all $u \geqslant w = w(\delta)$

$$|\,\varepsilon(u)\,| < \delta$$

$\therefore$ For all $x \geqslant w + 1$

$$\left| \sum_{n=2}^{[\sqrt{x}]-1} n\,\varepsilon(n) \left\{ \frac{1}{n(\log x - \log n)} - \frac{1}{(n+1)(\log x - \log \overline{n+1})} \right\} + \varepsilon\left([\sqrt{x}]\right) \frac{1}{(\log x - \log [\sqrt{x}])} \right|$$

$$< o(1) + \delta \sum_{n=w}^{[\sqrt{x}]-1} n \left\{ \frac{1}{n(\log x - \log n)} - \frac{1}{(n+1)(\log x - \log \overline{n+1})} \right\}$$

$$= \delta \sum_{n=w}^{[\sqrt{x}]} \frac{1}{n(\log x - \log n)} + o(1)$$

$$= \delta \int_{2}^{\sqrt{x}} \frac{du}{u\,(\log x - \log u)} + o\,(1) = \delta \log 2 + o\,(1) = o\,(1)$$

since δ can be taken to be arbitrarily small.

$$\therefore \sum_{p \leqslant \sqrt{x}} \frac{\log p}{p\,(\log x - \log p)} = \log 2 + o\,(1)$$

We have

$$\pi_2\,(x) = \sum_{p < \sqrt{x}} f\,(p)$$

where $f\,(p)$ denotes the number of numbers less than x, and which are products of two different primes, the less of which is equal to p.

$$\text{Since } f\,(p) = \pi\left(\frac{x}{p}\right) - \pi\,(p)$$

$$\therefore \quad \pi_2\,(x) = \sum_{p < \sqrt{x}} \pi\left(\frac{x}{p}\right) - \sum_{p < \sqrt{x}} \pi\,(p) \qquad \text{———} (1)$$

Now by Prime number Theorem.

$$\sum_{p < \sqrt{x}} \pi\left(\frac{x}{p}\right) = \sum_{p < \sqrt{x}} \frac{x}{p\,(\log x - \log p)} + O\left\{ \sum_{p < \sqrt{x}} \frac{x}{p\,(\log x - \log p)^2} \right\}$$

$$= \Sigma_1 + \Sigma_2$$

Now $p < \sqrt{x}$ $\quad \therefore \log p < \frac{1}{2} \log x$

$$\therefore \quad \frac{1}{\log x - \log p} < \frac{2}{\log x}$$

$$\therefore \quad \Sigma_2 = O\left\{ x \sum_{p < \sqrt{x}} \frac{1}{p\,(\log x)^2} \right\} = O\left\{ \frac{x}{(\log x)^2} \log \log x \right\} \qquad \text{———} (2)$$

$$\Sigma_1 = x \sum_{p < \sqrt{x}} \frac{1}{p\,(\log x - \log p)}$$

$$= \frac{x}{\log x}\left[\sum_{p < \sqrt{x}} \frac{1}{p} + \sum_{p < \sqrt{x}} \frac{\log p}{p\,(\log x - \log p)} \right]$$

$$= \frac{x}{\log x} \left\{ \log \log (\sqrt{x}) + B + o\,(1) \right\}$$

$$+ \frac{x}{\log x} \left\{ \log 2 + o\,(1) \right\} \qquad \text{by Lemma 2}$$

$$= \frac{x}{\log x} \left\{ -\log 2 + \log \log x + B + \log 2 + o\,(1) \right\}$$

$$= \frac{x}{\log x} \left\{ \log \log x + B + o\,(1) \right\} \qquad \ldots \quad \ldots \quad \ldots \quad (3)$$

$\therefore$ By (1) (2) and (3) and by Lemma (1)

$$\pi_2(x) = \frac{x}{\log x} \left| \log \log x + B + o(1) + o(1) + o(1) \right|$$

$$= \frac{x \log \log x}{\log x} + \frac{Bx}{\log x} + o\left(\frac{x}{\log x}\right)$$

AN EXPERIMENTAL INVESTIGATION OF DILUTE LIQUID AMALGAMS OF THE ALKALINE EARTHS WITH SPECIAL REFERENCE TO THEIR ELECTRICAL CONDUCTIVITY, VISCOSITY AND DENSITY

By

G. R. PARANJPE and V. S. PATANKAR

INTRODUCTIO

Recently a number of workers have studied the effect of concentration on the physical properties of dilute liquid amalgams of the alkali metals, and their endeavours have thrown some light on the constitution of these amalgams. Thus Bhatnagar, Prasad and Mukerjee[1] have investigated the surface-tension of liquid amalgams of Sodium and Potassium at the amalgam-benzene interface. Bhave[2] has studied the viscosities of the same amalgams. While Hine,[3] Bohariwalla, Paranjpe and Prasad,[4] and Evans Davies[5] have studied the electrical conductivities.

Unlike some other amalgams, the liquid amalgams of the Alkali metals do not follow the mixture law. The physical property-concentration curves of liquid amalgams of the alkali metals, however, show marked discontinuities at definite concentrations.

These discontinuities have been attributed by some to the formation of compounds or complexes, while others supporting the colloid hypothesis explain them as due to the sudden appearances of new phases. Bent[6] in a recent publication has however shown that the evidence in support of the colloid hypothesis is not conclusive.

Information regarding the liquid amalgams of the Alkaline earths is almost totally lacking. Only a few workers like K. Bornemann and G. V. Raushenplat[7] have determined some of the physical properties, but they confined themselves to one or two concentrations only.

It was, therefore, considered desirable to examine the effect of concetrations on the physical properties, such as electrical conductivities, viscosities and densities of these amalgams.

Before, however, such an investigation could be undertaken, it was necessary to determine the effect of time on the physical properties of these amalgams. For in a recent note by Paranjpe[8] it is pointed out that the viscosity of liquid sodium amalgams decreases

with time and that a mere mechanical agitation is sufficient to restore the initial value.

The results given later on show that no such changes take place in the electrical conductivity and viscosity of the amalgams of the alkaline earths, and it is possible, therefore, to investigate the effect of concentration on the physical properties. To observe the various stages that amalgams undergo on change of concentration, the composition of the amalgams have been varied by very small amounts of the amalgamated metal.

Next, an attempt has been made to verify the theory of electrical conductivity of liquid amalgams put forward by Skaupy.[15] From our experimental results, as well as those of two other workers from this laboratory—Bhave[2] and Bohariwalla[4]—are calculated certain quantities which are of importance in the theory of Skaupy.

Lastly it is shown how the view, taken by Lewis[9] regarding the constitution of amalgams, helps to explain satisfactorily, the behaviour of the liquid amalgams of the alkali metals and alkaline earths.

EXPERIMENTAL

The general experimental arrangement consists of the following:—

(i) The preparation of dilute liquid amalgams of the alkaline earth metals of the requisite concentrations.

(ii) Determination of the concentrations every time before and after the measurement of the physical property under examination.

(iii) Measurements of the different physical properties, viz. (*a*) electrical conductivity, (*b*) viscosity and (*c*) density.

The difficult nature of the problem is evident from the fact, that the alkaline earth amalgams are even more unstable under ordinary conditions than the alkali metal amalgams, and get oxidised very rapidly in air, especially when the latter is moist. All the operations had therefore to be carried out under an atmosphere of an inert gas like nitrogen.

I.—*Preparation of the amalgams.*

For the preparation of the amalgams the electrolytic method of T. W. Richards[10] was employed.

As the carbonates of the alkaline earths are very insoluble, saturated solutions of chlorides were employed as the electrolytes. Extra pure Merck's chemicals were used throughout.

Each time the same amount of mercury and the electrolyte was taken. The current strength was maintained at two amperes in all preparations. The different concentrations were obtained by varying only the time of electrolysis.

The amalgams thus prepared were cleaned, dried, and stored in an atmosphere of pure, dry nitrogen (Cf. Bhatanagar and others[1]).

Thus Barium amalgams with concentrations varying from 0·04 to 0·36 grams of Barium per 100 grams of amalgams were prepared. After attaining a concentration of about 0·36 grams % of Barium, the amalgam showed signs of solidifying and hence no higher concentrations were attempted. In the case of strontium amalgams the concentrations were varied from 0·05 to 0·44 grams % of Strontium. In the case of Calcium amalgams it was not possible to attain concentrations higher than 0·023 grams % of Calcium, for after a certain time of electrolysis, increase in the time of electrolysis was not effective in increasing the concentration. The amalgam seemed to decompose as fast as it was formed.

For every experiment a fresh amalgam was prepared.

II. *Estimation of the concentration* :

(Estimation was done by titration.) A detailed account of the method of estimation is given by Bhatnagar and others.[1]

(Phenolpthalene used as an indicator gave an end point within 0·1 C.C. of hydroxide. Thus using a 15 gram sample of amalgam, the probable error varied from 1·0 per cent for very dilute amalgams to to 0·2 per cent for amalgams of higher concentrations. Every time duplicate analyses of the amalgams were made and the difference between them was never more than 0·5 per cent.)

III. *The apparatus and the method of measurement* :—

(*a*) *The electrical conductivity.*—The electrical conductivity of amalgams has been measured by Bornemann and Muller,[11] Hine,[3] Williams,[12] T. I. Edwards,[13] A. L. Johns and E. J. Evans,[14] and Bohariwalla and others,[4] by the potentiometer method.

The same method for measuring the conductivities has been used in this investigation and a full description of it is given by Bohariwalla and others.[4]

The value of the standard resistance was 0·3410 ohm, and as the current strength chosen was about 29 milliamperes the potential difference across it was about 1×10^{-2} volts. The galvanometer was sensitive enough to give a deflection when the balance was upset by $3{\cdot}0 \times 10^{-6}$ volts.

Now $$Rm = \frac{Rk}{Lk} \times Lm.$$

where Rm = Resistance of cell containing the amalgam.

Rk = Resistance of the standard.

Lm = Fall of potential across the cell.

and Lk = Fall of potential across the standard.

$$\text{therefore } d(Rm) = \frac{Rk}{Lk} \times d(Lm)$$
$$= \frac{0.3410}{1.0 \times 10^{-2}} \times 3.0 \times 10^{-6}$$
$$= 0.0001 \text{ ohms approximately.}$$

Thus a change of resistance of 0·0001 ohm could be detected with this arrangement. (The actual error was much less than this as the mean of about ten observations with different current strengths was taken each time.)

(*b*) *Viscosity* :—The measurement of the coefficients of viscosity of these amalgams was first attempted by the Thorpe and Rodgers type viscometer. This type of viscometer was used by Bhave[2] for the measurement of viscosities of Sodium and Potassium amalgams. But the alkaline earth amalgams were found to stick to glass and thus the measurement of levels by means of a cathetometer became impossible. Moreover it was required to investigate the effect of time on the viscosities of the amalgams without disturbing them in any way, and this was not possible with the above-mentioned arrangement. It was therefore finally given up and an altogether new apparatus was designed.

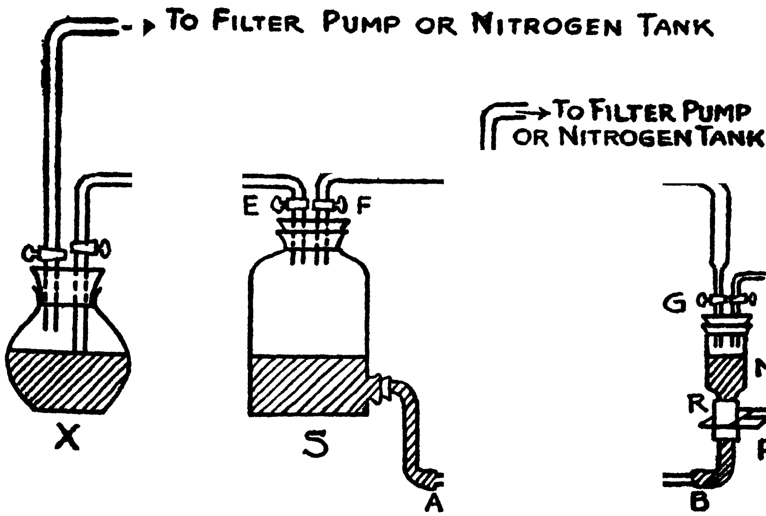


Fig 1.

The new apparatus as shown in fig. 1 consists of three parts. S is a bottle used as a storing vessel. V is the viscometer attached to S by means of a rubber cork *covered with a layer of paraffin wax.* The viscometer consists of a capillary tube A B, to the two ends of which were attached two broad glass tubes bent in the form as shown in fig. (1). The capillary, which was carefully calibrated and found to

be uniform, had a length of about 28 cms. and a bore of radius 0·03073 cm. M the small cylindrical measuring vessel of uniform bore was attached to the viscometer by means of a small piece of pressure tubing. Both the storing and the measuring vessels were closed by air-tight rubber corks. Through these corks passed glass tubes with stop-cocks and thus both these vessels could be connected either to the filter pump or to the tank of nitrogen. The measuring vessel M could be closed from the rest of the apparatus by means of a pinch cock P.

Before each experiment the different parts of the apparatus were disconnected, thoroughly cleaned and joined again as shown in fig. (1). To make the apparatus air-tight all the joints were covered on the outside with a layer of resin-wax mixture.

The vessel X containing the freshly prepared amalgam was then connected to the storing vessel S by means of two short pieces of pressure tubing and a glass tube as shown in fig. (1). The glass stopcock E was then closed and the further end of the viscometer V was closed by means of the pinch-cock P. Then F was opened and the vessel S and the viscometer V were evacuated as completely as possible. They were then filled with pure, dry nitrogen, and again evacuated. The stop-cock E was then opened, and after drawing by suction a sufficient quantity of the amalgam from X in S, the stop-cock E was again closed. The vessel X was then detached and S was filled with pure, dry nitrogen.

The whole apparatus was contained in an electrically operated air-thermostat. The temperature of the thermostat was maintained at a steady value of 30°C. The vessel M was adjusted in a vertical position and a slow steady stream of nitrogen was sent through the vessels S and M by opening F and G to the nitrogen tank and E and H to the atmosphere. As the stop-cocks E and H were opened to the atmosphere, both the vessels were at atmospheric pressure throughout the following procedure.

After adjusting the cathetometer, the pinch-cock P was released and the amalgam allowed to flow into M. The levels of the rising meniscus of the amalgam in M were noted down by the cathetometer against time, until a final steady level was reached. The level in S at any previous instant was calculated from the value of this steady level and the amount of amalgam that had flowed into M since then.

Knowing the levels of the meniscus in M at any two instants, the quantity of the amalgam that had flowed through the capillary of the viscometer during that interval could be calculated from the known cross-section of M. The pressure-head on the viscometer could be calculated from the levels in M and S. Thus all the quantities

necessary for the calculation of the coefficient of viscosity, from the equation,

$$\eta = \frac{\pi}{8} \frac{g\rho h}{Q} \frac{a^4}{l} t.$$

for the flow through a capillary, were known, except ρ, the density, which was determined each time by a separate experiment. The coefficient of viscosity could thus be calculated.

No kinetic energy correction need be applied, as only relative values of the coefficients of viscosity are required.

The final steady level which the amalgam would attain was approximately known before-hand. The cathetometer was adjusted about a centimeter below this and as soon as the meniscus passed this level a stop-watch was started. The cathetometer was then adjusted one or two millimeters higher, and the time noted in the stop-watch when the meniscus passed the cross-wire. This procedure was followed until the steady state was attained. The measurements of heights and times were thus made in succession, and an error committed either in the measurement of level or time in one observation, resulted in an equal and opposite error in the next observation. Thus in the calculation of the coefficient of viscosity the error from one observation was partly eliminated by about an equal and opposite error in the next. Thus the mean of about six or seven consecutive observations yields quite a reliable value.

The error in an individual observation was from 2 to 3 per cent; but since each experiment consisted of about six or seven consecutive observations and, as explained above, the error in one observation was partly neutralised by about an equal and opposite error in the next, the probable error in the mean was never more than 0·5 per cent. This is quite evident from the following values of the coefficients of viscosity of mercury obtained with the apparatus at three different times:—

Temperature.	η obtained by the author.	η calculated from S. Koch's formula	% error.
31·0°C.	0·01514	0·01511	0·20
31·0°C.	0·01513	0·01511	0·13
32·0°C.	0·01512	0·01506	0·39

(c) *Density*:—The densities of the amalgams were determined under liquid paraffin by means of a specific gravity bottle.

The amalgam was never exposed to the air except during the act of transferring it to the specific gravity bottle. The determinations of

the coefficients of viscosity and density were made at the same temperature.

RESULTS

(i) *Effect of time on the physical properties of amalgams of the alkaline earth metals.*

A large amount of amalgam was prepared and stored under an atmosphere of pure, dry nitrogen, so that it kept its strength unaltered during the course of the experiment. The physical property, *i.e.* either the electrical conductivity or the viscosity was determined from day to day as described in the experimental part.

The results of the experiments are given in Tables I and II.

Effect of time on the amalgams.

TABLE I.—Electrical Conductivity.

Time.	BARIUM		STRONTIUM	
	Concentration.	Resistivity. $\times 10^{-6}$	Concentration.	Resistivity. 10^{-6}
First day	0·1337	96·81	0·0552	96·54
Second day	0·1331	96·83	0·0550	96·56
Third day	0·1325	96.79	...	...
First day	0·2853	96·91	0·1714	96·10
Second day	0·2850	96·92	0·1733	96·12
First day	...	...	0·4545	94·80
Second day	...	...	0·4662	94·80

Effect of time on the amalgams.

TABLE II.—Viscosity.

Time	BARIUM		STRONIUM	
	Concentration.	Viscosity.	Concentration.	Viscosity.
First day	0·2026	0·01737	0·0751	0·01644
Second day	0·2010	0·01741	0·0735	0·01630
Third day	0·2008	0·01751	...	...
First day	0·2389	0·01748	0·1057	0·01678
Second day	0·2346	0·01748	0·1045	0·01678
First day	0·1789	0·01681	...	...
Second day	0·1785	0·01700	...	...
First day	0·1525	0·01692	...	...
Second day	0·1519	0·1698	...	...

Viscosity determinations in the case of Barium amalgams were made at 32° C., while those of the Strontium amalgams were made at 30° C.

The results show that, in the case of these amalgams, no changes take place, with time, in the electrical conductivity and viscosity. The slight changes, that are observed, are within the limits of experimental errors. It was, therefore, concluded that the amalgams of Barium and strontium metals are fairly homogeneous and stable.

Incidentally these experiments prove that the amalgams keep up their concentrations, when stored under the conditions employed. They also furnish evidence for the reproducibility of the results.

(ii) *Variation of the electrical conductivity with concentration.*

The results of the determinations of electrical conductivities at different concentrations ot Barium, Strontium and calcium amalgams are given in table III, IV and V respectively. In each case the concentration has been expressed in two ways, once in terms of the number of gms. of the metal in 100 gms. of the amalgam, and second time in number of gm-atoms of the metal in 100 gm-atoms of mercury.

TABLE III

Electrical conductivities of Barium amalgams at 30°C.

Resistivity of mercury at 30°C. $= 96{\cdot}69 \times 10^{-6}$

Conductivity „ „ „ „ $= 1{\cdot}0342 \times 10^{4}$

Concentration		Resistivity of amalgam $\times 10^{-6}$	Conductivity of amalgam $\times 10^{4}$
in gms. % of Ba.	in gm-atoms % of Ba.		
0·0412	0·0602	96·77	1·0333
0·1285	0·1878	96·96	1·0313
0·1337	0·1954	96·81	1·0329
0·1805	0·2640	96·87	1·0323
0·2040	0·2983	96·90	1·0320
0·2249	0·3291	96·83	1·0327
0·2338	0·3422	96·83	1·0327
0·2658	0·3890	96·88	1·0323
0·2853	0·4178	96·91	1·0319
0·3200	0·4687	96·96	1·0313
0·3327	0·4874	96·80	1·0330
0·3351	0·4906	96·79	1·0331
0·3572	0·5234	96·85	1·0325

TABLE IV

Electrical conductivities of Strontium amalgams at 30°C.

Resistivity of mercury at 30°C. = $96{\cdot}69 \times 10^{-6}$

Conductivity „ „ „ „ = $1{\cdot}0342 \times 10^{4}$

Concentration		Resistivity of amalgam × 10^{-6}	Conductivity of amalgam × 10^{4}
in gms.% of Sr.	in gm-atoms. % of Sr.		
0·0552	0·1264	96·54	1·0356
0·1297	0·2974	96·27	1·0386
0·1714	0·2877	96·10	1·0406
0·2201	0·5051	95·94	1·0423
0·2890	0·6636	95·66	1·0453
0·3877	0·8910	95·30	1·0492
0·4275	0·9833	95·01	1·0526
0·4545	1·0460	94·80	1·0547

TABLE V

Electrical conductivities of Calcium amalgams at 30°C.

Resistivity of mercury at 30°C. = $96{\cdot}69 \times 10^{-6}$

Conductivity „ „ „ „ = $1{\cdot}0342 \times 10^{4}$

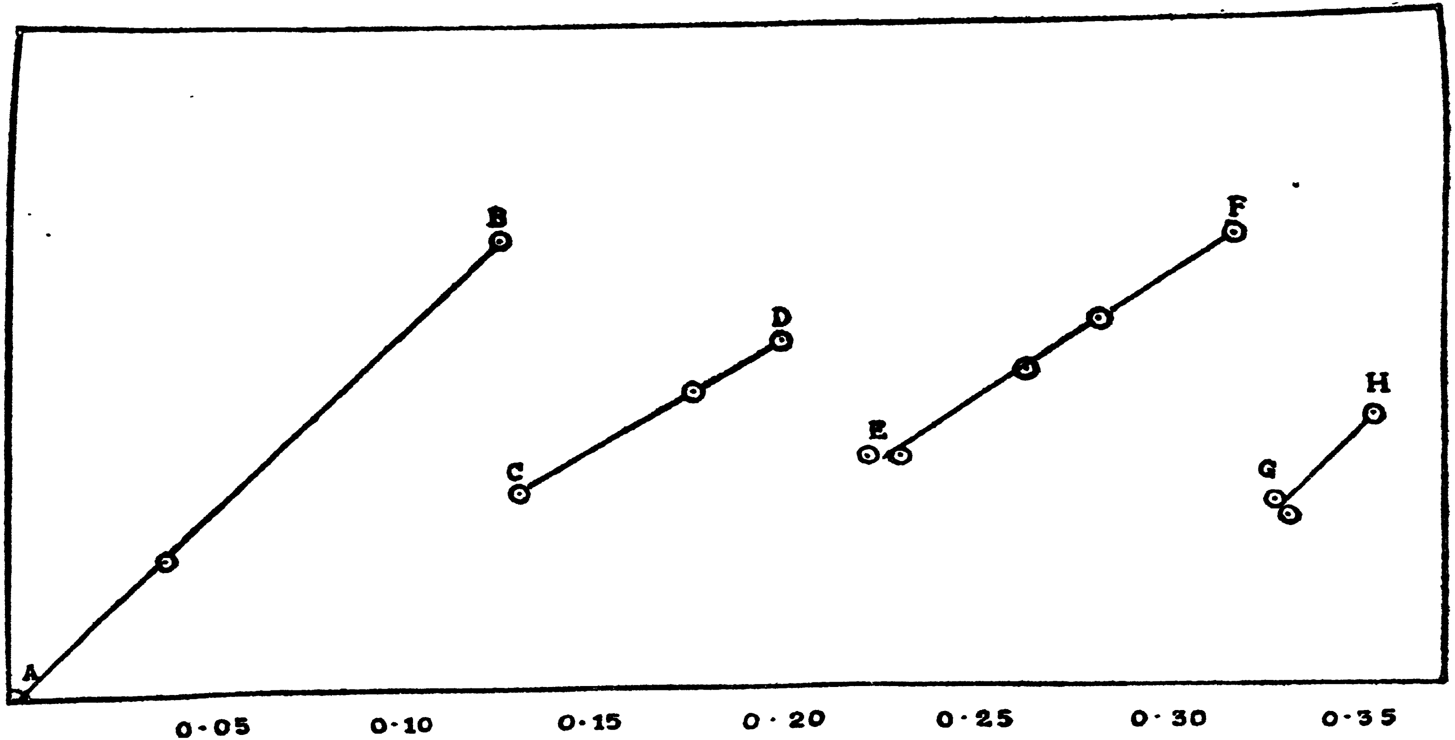
Concentration		Resistivity of amalgam × 10^{-6}	Conductivity of amalgam × 10^{4}
in gms.% of Ca.	in gm-atoms % of Ca.		
0·0097	0·0485	96·56	1·0356
0·0206	0·1031	96·46	1·0366
0·0225	0·1127	96·40	1·0373
0·0236	0·1181	96·40	1·0373

The resistivities of all the three amalgams are plotted down as ordinates against their respective concentrations as abscissa and the curves so obtained are given in figs. (2), (3) and (4).

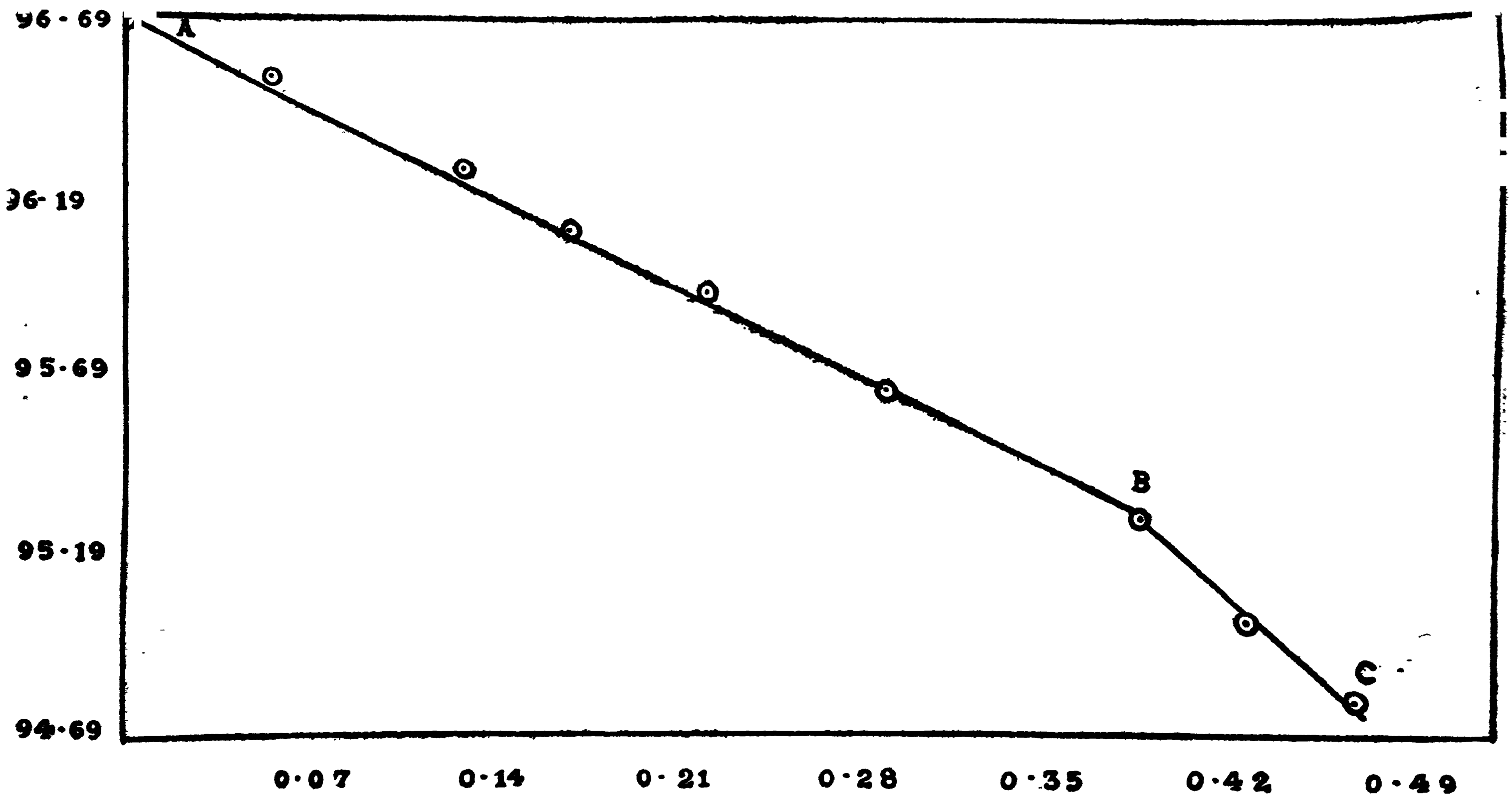
Starting with pure mercury at the point A fig. (2) the resistivity of Barium amalgam increases uniformly with concentration until it reaches a maximum at about the point B, corresponding to the concentration 0·130 gms. % Barium. After this concentration, there is a sharp break in the curve with an abrupt decrease in the resistivity.

From the point C the resistivity again increases uniformly with concentration till the second discontinuity is reached at the point D, corresponding to the concentration of about 0·225 gms. % Barium.

A third discontinuity occurs at the point F, corresponding to the concentration of about 0·325 gms. % Barium.

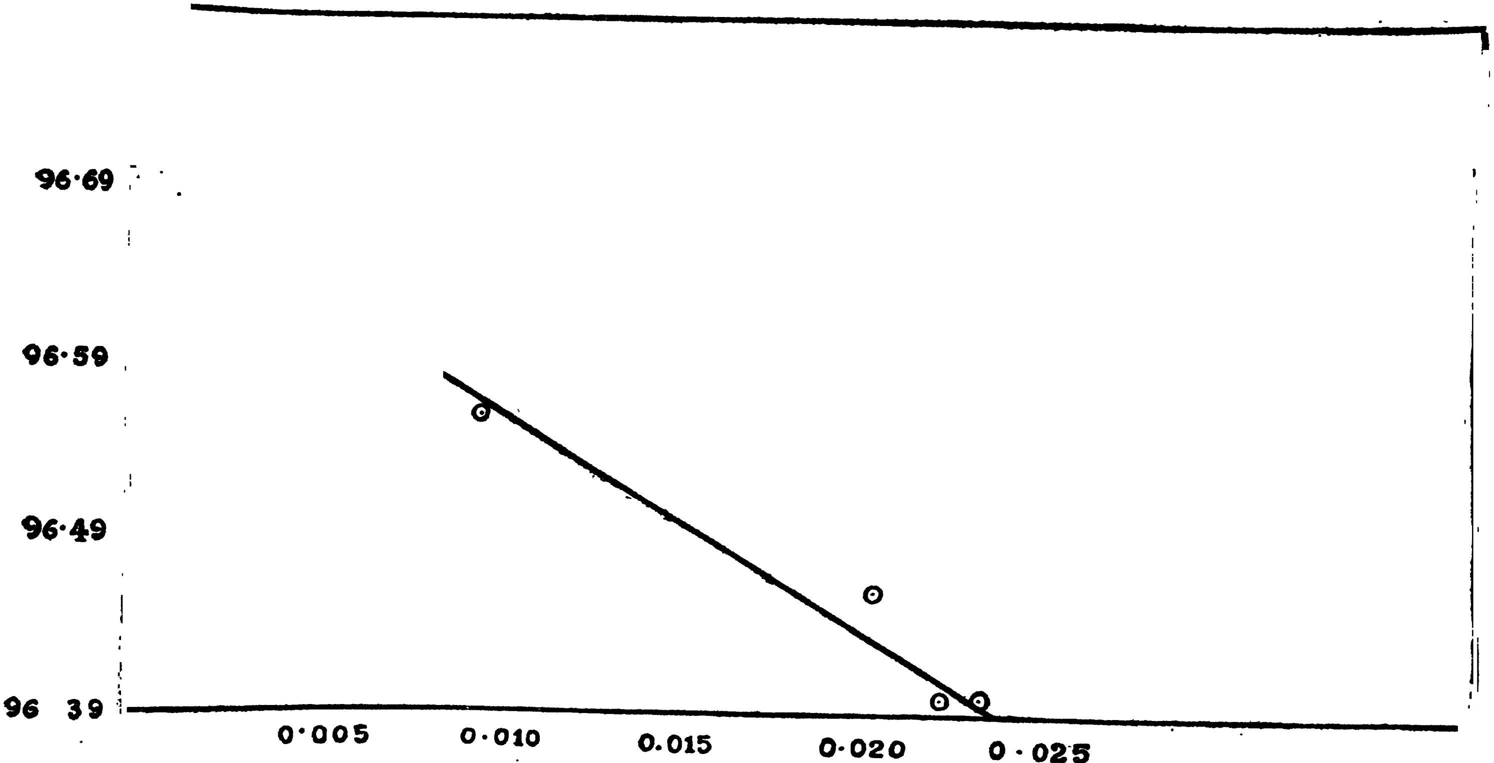


Concentration of Barium in grams per 100 grams of amalgams.
Fig. 2



Concentration of Strontium in grams per 100 grams of amalgam.

Fig. 3



Concentration of Calcium in grams per 100 grams of amalgam.
Fig. 4.

In the case of Strontium the addition of this metal decreases the resistivity of mercury. Thus starting with pure mercury at the point A fig. (3), the resistivity decreases uniformly with concentration till the point B, corresponding to the concentration of about 0·39 gm. % Strontium, is reached. After this concentration the rate of decrease of resistivity with concentration suddenly increases.

The range investigated in the case of Calcium amalgam is small; but in this region of concentrations the amalgam exhibits no peculiarities, and the resistivity decreases uniformly with concentration.

(iii) *Variation of viscosity with concentration*:—

This investigation was confined only to the Barium amalgams; for of the three amalgams under consideration it is only the Barium amalgam that exhibits discontinuities on the conductivity-concentration curve. The results of the investigation are given in table 6.

TABLE VI.

Viscosities of the Barium amalgams at 32° *C.*

Coefficient of Viscosity of mercury at 32° C. = 0·01506
Density „ „ „ „ = 13·516 gm/c.c.

Concentration.		Density in gms. per c.c.	Coefficient of viscosity.
in gms. % of Ba.	in gm-atoms % of Ba.		
0·0540	0·0789	13·50	0·01593
0·0844	0·1233	13·50	0·01656
0·1238	0·1810	13·49	0·01736
0·1522	0·2225	13·48	0·01695
0·1787	0·2613	13·47	0·01690
0·2026	0·2964	13·47	0·01737
0·2367	0·3463	13·47	0·01748
0·2671	0·3910	13·46	0·01708
0·3018	0·4419	13·46	0·01776
0·3124	0·4576	13·45	0·01794
0·3443	0·5044	13·44	0·01773
0·3641	0·5334	13·44	0·01731

As can be gathered from table 6, the general effect of adding Barium even in small quantities to mercury is to increase the viscosity considerably. The coefficients of viscosity of twelve different Barium amalgams, containing from 0.0540 gms. % to 0.3641 gms. % of Barium have been determined.

The viscosity coefficients of the Barium amalgams have been plotted as ordinates against the respective concentrations as abscissa, and the curve so obtained is given in fig. 5

The results definitely indicate the existence of three maxima in the curve, in the range investigated, and that these maxima are situated at about the concentrations 0.125, 0.220 and 0.323 gms. % of Barium, i.e., at almost the same concentrations at which the discontinuities occur in the electrical conductivity concentration curve (fig. 2)

(iv.) *Variation of Density with concentrations* :—The determinations of the densities were also confined only to the Barium amalgams. The results are given in column three, table VI.

The density uniformly decreases with increase in concentration, and the density concentration curve exhibits no peculiarities. (Fig. 6) If such actually exist, they are not prominent enough to be detected by method of measurement employed here.

(v) *Verification of Skaupy's theory* :—Skaupy[15] bases his theory on an analogy between liquid metals and electrolytic solutions, and assumes that the electrical conductivity of a pure solvent must be expressed as a function of the concentration of electrons and of the internal friction i. e., viscosity.

He further assumes that dilute metallic solutions must show a higher electron concentration than the solvent as splitting off of the electrons occurs when the dissolved substance dissociates. The splitting up of neutral molecules into ions and electrons is in accord with the law of mass action.

The conductivity L of a metallic liquid is proportional to the electron concentration s, and inversely proportional to the internal friction (viscosity) η, and can be written

$$s = \text{constant} \times L \times \eta \quad \ldots\ldots \quad (1)$$

Taking logarithms of both sides and differentiating we obtain

$$\frac{1}{s}\Delta s = \frac{1}{L}\Delta L + \frac{1}{\eta}\Delta\eta \quad \ldots\ldots \quad (2)$$

Let C = concentration of the substance dissolved in mercury expressed in gm. atoms per hundred gm. atoms of mercury. Dividing by C the equation (2) becomes

$$\frac{1}{s}\frac{\Delta s}{C} = \frac{1}{L}\frac{\Delta L}{C} + \frac{1}{\eta}\frac{\Delta\eta}{C} \quad \ldots\ldots \quad (3)$$

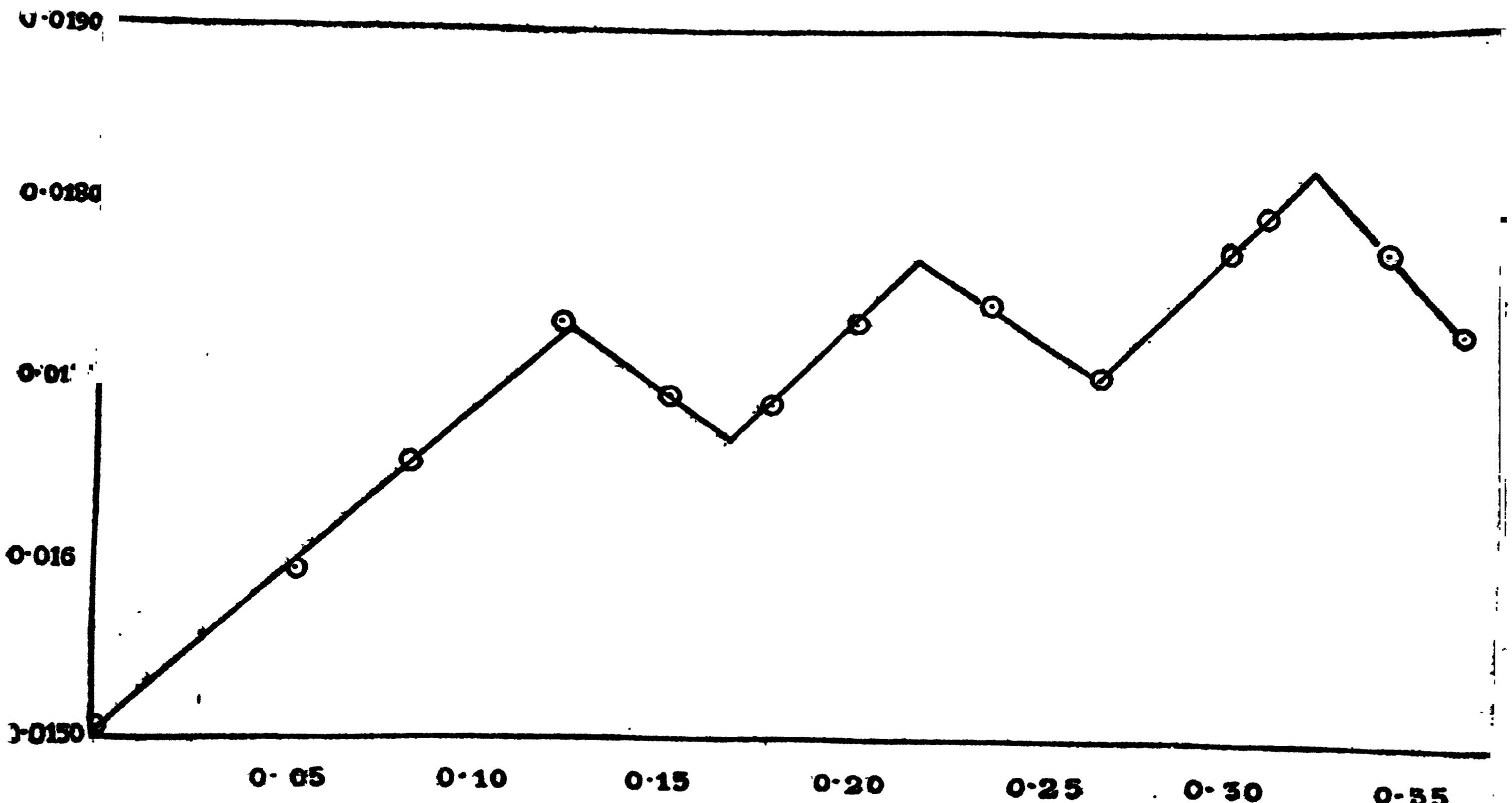
Δ expresses that we are dealing with finite changes however small corresponding to small but finite concentrations, and we can substitute for L and η the values for the pure solvent.

Putting

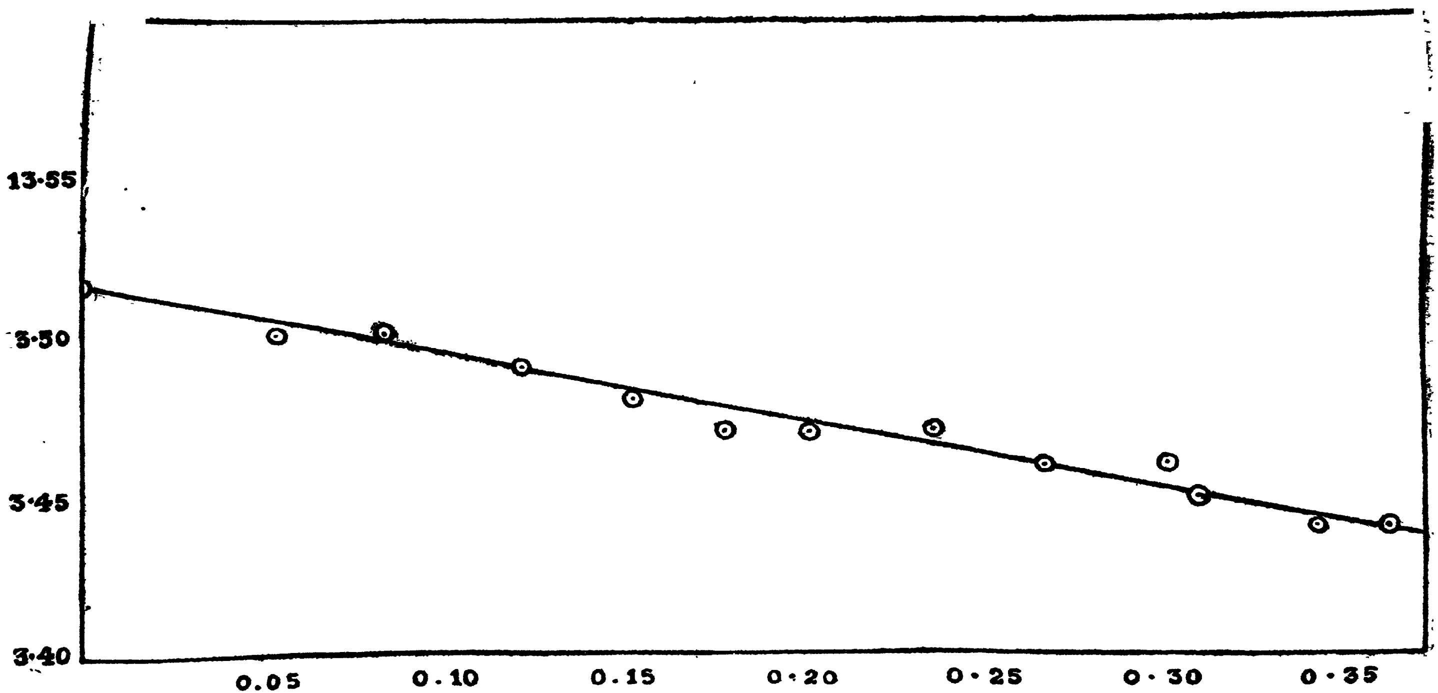
$$\frac{1}{s}\frac{\Delta s}{C} = H, \quad \frac{1}{L}\frac{\Delta L}{C} = l \quad \text{and} \quad \frac{1}{\eta}\frac{\Delta\eta}{C} = r$$

we obtain from (3).

$$H = l + r$$



Concentration of Barium in grams per 100 grams of amalgam.
Fig. 5



Concentration of Barium in grams per 100 grams of amalgam.
Fig. 6.

55

which for infinite dilution can be expressed as

$$H_{\alpha} = l_{\alpha} + r_{\alpha}$$

Skaupy showed in the first paper that $l\alpha$ has approximately the same value for a number of metals dissolved in mercury.

The rule that $l\alpha$ has approximately the same value for all metals does not hold in the case of some alkali amalgams, for l has a negative value in these cases. The difficulty was not removed until H. Fenniger's work[16] showed the increased value of the viscosity for these amalgams.

If this is taken into account, we obtain the more general rule that

$$H_{\alpha} = l_{\alpha} + r_{\alpha}$$

should have the same order of magnitude for different metals dissolved in mercury.

The necessary quantities are calculated and are entered in table 7.

TABLE VII.

Co-efficient of viscosity of mercury at 30° C. = 0·01516.
Electrical conductivity " " " = $1{\cdot}0342 \times 10^4$.

	Concentration. (C)	Conductivity $\times 10^4$ (L)	Viscosity co-efficient (η)	$\frac{\Delta L}{L}\frac{1}{c}=l$	$\frac{\Delta n}{n}\frac{1}{c}=r$	$H=l+r$
Ba. Amalgam	0·1810	1·0317	0·01736.	-0·0134	0·8437	0·8303
	0·2964	1·0320	0·01737	-0·0072	0·5175	0·5103
	0·4419	1·0316	0·01776	-0·0056	0 4049	0·3992
	0·5044	1·0328	0·01773	-0·0027	0·3516	0·3489
Sr. Amalgam	0·1264	10·356	0·01598	0·0092	0·4224	0·4316
	0.2974	1·0386	0·01708	0·01269	0·4233	0·4360
Na. Amalgam	0·4571	1·0178	0 0226	-0·07381	1·081	1·004
	2·604	1·0247	0 01856	-0·0028	0·0833	0·0805
K. Amalgam	0·3482	1·0058	0 01858	-0·07886	0·6045	0·5257
	0·3594	1·0027	0·01767	-0·05446	0·2823	0.2279

N.B.—These conductivity and viscosity values of the amalgams are at about 30°C. Values of the electrical conductivities and viscosities for the Sodium and Potassium amalgams have been obtained from the works of Bohariwala[4] and Bhave.[2]

The values of H are given in the last column of table 7 for four different amalgams viz., those of Barium, Strontium, Sodium, and Potassium.

The values of H have a tendency to increase with decreasing concentrations in all except the Strontium amalgam. Thus it appears that

values of $H\alpha$ for these amalgams will have a much greater value than those at the concentrations given.

The values of $H\alpha$ for Gold and other amalgams have been shown by Skaupy,[15] Williams,[12] etc., to be of the order of 0·10. Thus values of $H\alpha$ for these amalgams will differ appreciably from the values expected from the rule that $H\alpha$ is of the same order of magnitude for all metals dissolved in mercury. It, thus, seems that this rule does not hold good for the four amalgams examined.

DISCUSSION.

The results of the work done on dilute liquid amalgams of Barium by the authors and other workers bring out the remarkable similarity betweem this amalgam and those of Sodium and Potassium. Thus Barium, like Sodium and Potassium when dissolved in mercury lowers the conductivity of the latter. The conductivity-concentration curve of Barium amalgam exhibits discontinuities at certain concentrations. The conductivity-concentration curves of Sodium and Potassium also exhibit similar discontinuities (Bohariwala[4]). The viscosity-concentration curve of Barium amalgam shows maxima at the concentrations where the discontinuities exist on the conductivity-concentration curve. The viscosity-concentration curves of Sodium and Potassium amalgams also exhibit similar maxima (Bhave[2]). On the passage of an electric current through dilute liquid amalgams of Sodium, Potassium and Barium, the amalgamated metal gathers round the anode (Lewis, Adam and Lanmann[9]; Le Blanc and Jäcks[17]). But the transference of the metals, Sodium, Potassium and Barium, towards the anode holds good upto a certain concentration only (2.0% Na, 2·5% K. and 2.7% Ba); after this concentration a reversal in the direction of migration takes place, in each case towards the cathode (R. Kremann and co-workers[18]). Thus the behaviour of dilute liquid amalgams of Barium is in every respect similar to the behaviour of the dilute liquid amalgams of Sodium and Potassium.

The Strontium and Calcium amalgams, however, resemble the Lithium amalgam. On the addition of Strontium or Calcium the electrical conductivity of mercury increases. Lithium when dissolved in mercury has also been shown to increase the conductivity of the latter (Hine[8] and Bohariwala[4]). On the passage of a current through dilute liquid amalgams of these metals, the amalgamated metal gathers round the cathode in each case (Le Blanc and Jacks[17]; R. Kremann and co-workers[18]).

The dilute liquid amalgams of the alkali and alkaline earth metals can thus be grouped into two classes. The first comprises the Sodium, Potassium and Barium amalgams and the second those of Lithium, Strontium and Calcium.

The outstanding features of the first group are that, the electrical conductivities of amalgams belonging to this group are less than that of pure mercury, and that on the passage of a current through these dilute amalgams, the amalgamated metal travels to the anode.

The features of the second group are that, the electrical conductivities of amalgams in this group are greater than that of pure mercury, and that on the passage of a current through dilute liquid amalgams of this group, the amalgamated metal goes to the cathode.

The behaviour of both these groups can be explained in the following manner.

When a metal is dissolved in a non-metallic solvent, as Sodium in liquid ammonia, it dissociates according to the theory of Kraus,[19] into positive ions (sodium ions) and negative electrons, which may be, in part, combined with the molecules of the solvent. When an electric current is passed through such a solution, the dissolved metal is carried with the positive current.

It does not seem unreasonable if we assume, like Lewis, Adams and Lanmann[9] that the alkali and alkaline earth metals, when dissolved in a far less positive metal like mercury, would behave in a like manner.

Thus any of these metals, when dissolved in mercury would get ionised to a considerable extent, the concentration of electrons would increase and there would be an increase in the conductivity of the amalgam. Moreover on the passage of a current through dilute amalgam of any of these metals the positive ion (the alkali or alkaline earth metal ion in this case) would travel towards the cathode.

But, as mentioned earlier, experiments prove that the behaviour of dilute solutions of Sodium, Potassium and Barium in mercury is exactly contrary.

Lewis, Adams and Lanmann[9] have explained this peculiar behaviour in the following words :—

" A clue to the interpretation of this apparently mysterious transference effect in amalgams is found when we examine the curves relating the electrical conductivities and the compositions of liquid amalgams of Sodium and Potassium. Bornemann and Muller have shown that the electrical conductivity of mercury is lowered by the addition of Sodium.

Now, unless the Sodium diminishes the number of electrons which take part in the conduction, which seems improbable, this change of conductivity must be due to a diminution of the average mobility of the electrons. Probably the atoms of Sodium which are dissolved in mercury, are not there chiefly as such, but rather as nuclei of large aggregates of mercury atoms. Be this as it may, we can consider a dilute amalgam as composed of small regions whose centres are the

Sodium atoms, embedded in a mass which has all the properties of pure mercury. If an electron meeting one of these regions during the passage of the current is on the average retarded, whether by the greater impenetrability of that region or by any kind of reflection or refraction then, by the law of action and reaction, the region containing the Sodium atom will be impelled in the direction of the negative current."

This explanation of Lewis, Adams and Lanmann[9] at once explains the decrease in conductivity and the transference of the amalgamated metal towards the anode in the case of Sodium, Potassium and Barium amalgams. But this assumption of the process of solvation, or the combination with the solvent, is not only necessary to explain the behaviour of Sodium, Potassium and Barium amalgams. This hypothesis is necessary in the case of Calcium, Strontium and Lithium amalgams. For the amalgams of the alkali and alkaline earth metals behave abnormally as regards their vapour pressure, solution tensions and diffusion velocities (Ramsay[20]; C. McP. Smith[21]). The assumption of solvation satisfactorily explains these abnormalities.

C. McP. Smith[21] explained this behaviour on the assumption that compound formation takes place and the molecule of the compounds thus formed contains only one atom of the amalgamated metal and a number of atoms of mercury. This his idea of compound formation is not however much different from the solvation process which Lewis, Adams and Lanmann imagine.

It can thus be assumed that an alkali or alkaline earth metal on going into solution in mercury first gets ionised, splitting into electrons and positive ions. The mercury atoms then gather on the positive ions, thus forming an aggregate of mercury with the positive ion as nucleus. The degree of solvation is, however, different for different metals.

The concentration of the electrons is thus increased, but the electrical conductivity which depends also on the mobility of electrons will increase or decrease according as the mobility of the electrons increases or decreases. If the solvation is considerable the mobility of electrons, as explained above, decreases considerably and the conductivity decreases; but if the solvation is not much, the mobility of the electrons is not changed appreciably and the conductivity increases.

The positive ion with its aggregate of mercury atoms has a tendency, due to the imposed E.M.F., to travel towards the cathode; but due to the bombardment of the electrons, on the passage of the electric current, the positive ion with its aggregate of mercury atoms is repelled towards the anode. The direction of transference of the metal depends on which of these two tendencies predominates. If there is good deal of solvation the amalgamated metal is forced towards the anode. If

the solvations is not appreciable the amalgamated metal moves towards the cathode. Thus whether the conductivity will decrease and the metal will travel towards the anode or whether the conductivity will increase and the amalgamated metal will travel towards the cathode is determined by the degree of solvation which the metal undergoes. If the solvation is considerable the conductivity decreases and the metal travels towards the anode. To this class belong the dilute amalgams of Sodium, Potassium and Barium. If the solvation is not considerable, the conductivity increases and the metal travels towards the cathode. This is what happens in the case of dilute amalgams of the Lithium, Strontium and Calcium metals.

The reversal in the direction of migration during electrolysis which R. Kremann[18] and others observed in the case of liquid Sodium, Potassium and Barium amalgams at concentrations 2·0% Sodium, 2·5% Potassium and 2·7% Barium, can be explained as the tendency, of going to the cathode, of the positive ion with its aggregate of mercury atoms, attaining predominance at these concentrations over its repulsion towards the anode due to the bombardment of electrons.

The departure exhibited by the amalgams of Sodium, Potassium, Barium and Strontium from Skaupy's theory of conduction, for the liquid amalgams, becomes clear from this point of view; for Skaupy assumed that the amalgamated metal dissociates into electrons and positive ions on going into solution with mercury and that the positive ions exist as such in the solution. But due to the solvation that takes place, the viscosity increases abnormally, and the value of $H\alpha$ in these cases has therefore a much higher value than those for other metals.

The assumption of the process of solvation is further supported by the investigations of Bhave[2] on the viscosities of dilute amalgams of Sodium, and Potassium, and those of the authors on Barium amalgams, record in this paper. The viscosity-concentration curves of these amalgams show maxima at certain concentrations. These maxima are held to indicate some form of molecular aggregation (A. E. Dunstan and Thole, *Viscosity of Liquids* pp. 46).

SUMMARY.

The experimental investigation is confined to the dilute liquid amalgams of the alkaline earth metals. The concentration ranges investigated are as follows:—

0.000 to 0.364	gms.	% of Barium,
0.000 to 0.4545	„	„ „ Strontium,
0.000 to 0.023	„	„ „ Calcium.

(1) The electrical conductivities and viscosities of Barium and Strontium amalgams suffer no change with time,

(2) The electrical conductivity of mercury decreases on the addition of Barium, and the electrical-conductivity-concentration curve of Barium amalgam exhibits discontinuities at the concentrations, 0·130, 0.225 and 0.325 gms. % of Barium. The electrical conductivities of Strontium and Calcium amalgams increase uniformly with concentration.

(3) The viscosity of mercury on the addition of Barium increases and viscosity-concentration curve of Barium amalgam exhibits maxima at the concentrations at which the discontinuities occur on the electrical-conductivity-concentration curve.

(4) The density of Barium amalgam decreases uniformly with concentration.

(5) The behaviour of dilute amalgams of the alkali and alkaline earth metals is examined in the light of different theories, particularly those of Skaupy and Lewis.

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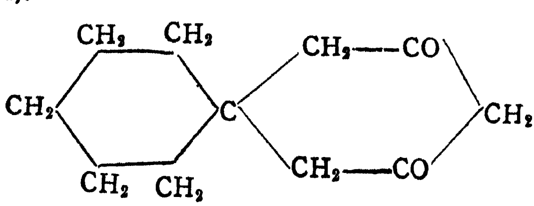
DIHYDRORESORCINOLS PART III. THE CONDENSATION OF ALDEHYDES WITH CYCLOHEXANE-SPIRO-CYCLOHEXANE-3:5-DIONE.

By

RANCHHODJI DAJIBHAI DESAI.

In continuation of the author's work on dihydroresorcinols [J.C.S.T. (1932), 1079. also in press.] it was thought interesting to condense the spiro compound, cyclohexane-spiro-cyclohexane- 3:5-dione (1) with aldehydes in order to see how far its behaviour resembled that of dimethyldihydroresorcinol, as it has, sometimes, been observed that the derivatives of cyclohexane differ chemically from their dimethyl analogues. [Compare Desai J. C.S. (1932) 1081; Beesley Ingold and Thorpe, J.C.S. (1915), 1081; Qudrar-i-Khuda. J.C.S. (1929), 201.]

The action of benzaldehyde and salicylaldehyde on the dione (I) at the ordinary temperature, in presence of piperidine as a condensing agent, gave benzal-bis-cyclohexane-spiro-cyclohexane-3:5-dione (II) and salical-bis-cyclohexane-spiro-cyclohexane-3:5-dione (III). Under the influence of dehydrating agents like acetic anhydride, glacial acetic acid or gaseous hydrogen chloride, the compound (II) gave rise to 2-spiro-cyclohexane-4: 5-diketo-7-spiro-cyclohexane-9-phenyl-octahydroxanthene (IV). The dehydration of the salical derivative (III) can give rise to, either, the octahydroxanthene derivative (V) or the pyran derivative (VI).



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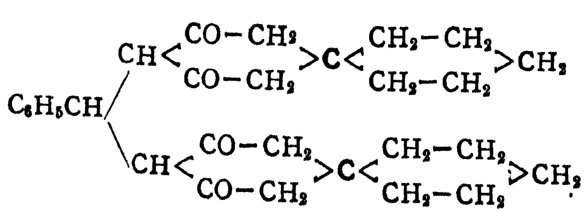

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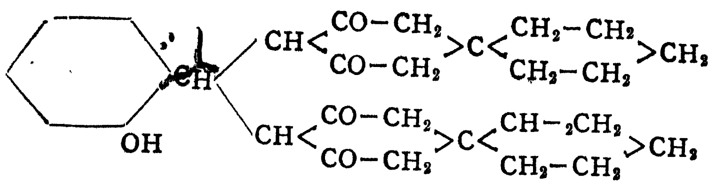

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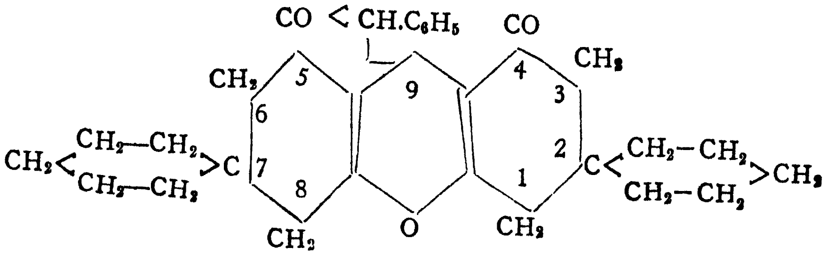

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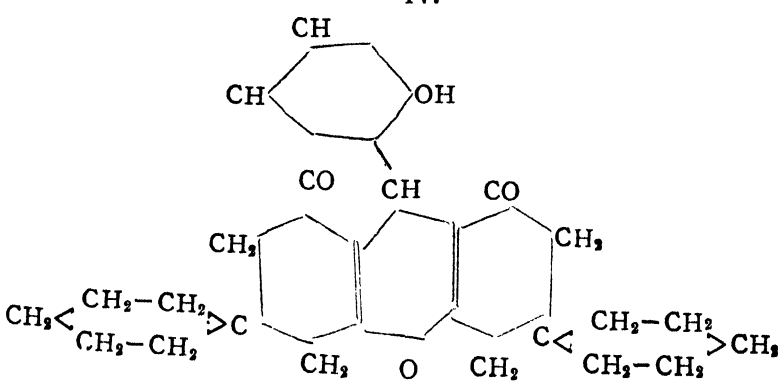

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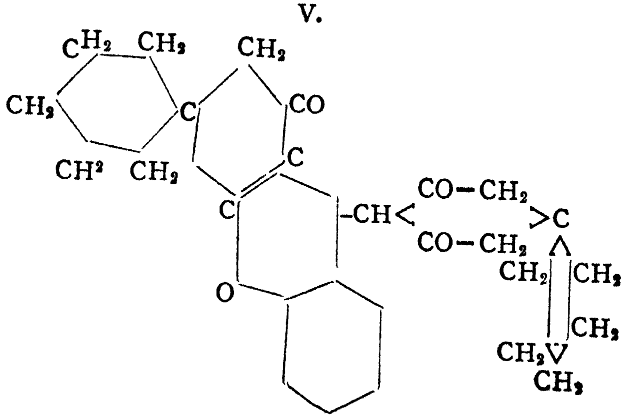
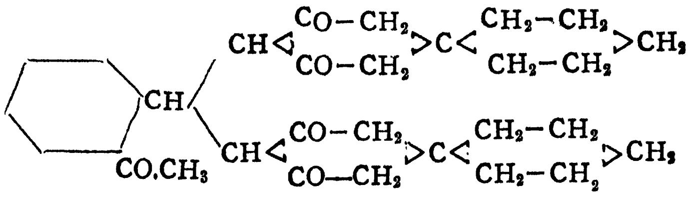


VI.

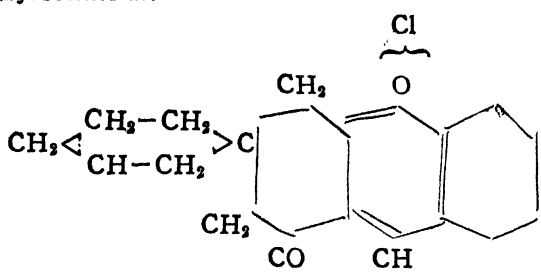
That the actual product formed is the octahydroxanthene derivative (V) is proved by the fact that when acetylsalicylaldehyde is con-

densed with the dione (I), the acetyl-salical-bis-cyclohexane-spiro-cyclohexane-3: 5-dione (VII), which is first formed, undergoes dehydration to the xanthene derivative, which is formed by the acetylation of (V).



VII.

The Condensation of salicylaldehyde with the dione (1) in presence of gaseous hydrogen chloride as a condensing agent took a different course, and a scarlet compound was formed. This was found to be 2-spiro-cyclohexane-4-keto-tetrahydrobenzo-pyranol-anhydrochloride [(VIII) or (VIII)A]. Of the two alternative formulæ (VIII) or (VIII,A), the latter is preferred because the presence of the Ortho-quinonoid grouping in the benzene nucleus explains satisfactorily the colour of the anhydrochloride.



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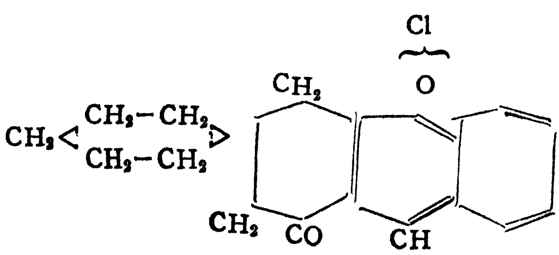
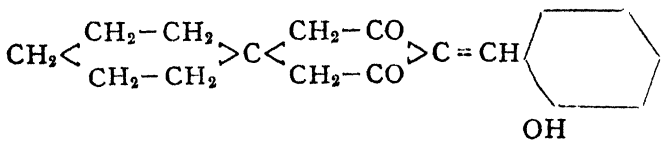


VIIIA.

The formation of the anhydrochloride (VIII,A) must have involved the intermediate formation of salicylidene-cyclohexane-spiro-cyclohexane-3 : 5-dione (IX), but attempts to prepare it by the condensation of salicylaldehyde with the dione (1) either alone or under the influence of various alkaline as well as acid catalysts failed. Efforts were, then

made to prepare it by the alkaline hydrolysis of (VIII,A); but the anhydrochloride was found to be extraordinarily resistant to the hydrolytic action of Caustic alkali. The only product that could be isolated was the free base (X) corresponding to the anhydrochloride. Thus the behaviour of cyclohexane-spiro-cyclohexane-3: 5-dione, was similar to that of dimethyldihydroresorcinol, so far as the condensation of benaldehyde and salicyl-aldehyde was concerned.



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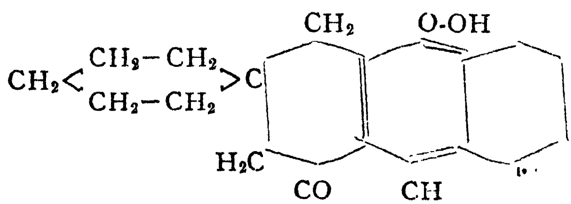

X.

Experimental.

Cyclohexane-Spiro-cyclohexane-3:5-dione was prepared by the method of Norris and Thorpe [J. C. S. (1921), 1205]. When its alcoholic solution was treated with an excess of [40%] formaldehyde solution at ordinary temperature, *methylene-bis-cyclohexane-spiro-cyclohexane-3:5-dione* was immediately precipitated, and melted at 206° according to the above authors.

2-Spiro-cyclohexane-4: 5-diketo-7-spiro-cyclohexane-octahydroxanthene. The above methylene derivative (1 g.) was heated with acetic anhydride (5cc.) on a free flame for 2 hours, and the excess of the anhydride decomposed by adding water. The precipitated solid was crystallised from dilute alcohol when white, prismatic needles melting at 215° were obtained. It was soluble easily in acetone, and glacial acetic acid, but sparingly in benzene (found C, 77·8 ; H, 8·6 ; $C_{23}H_{30}O_3$ requires C, 78·0 ; H, 8·47 percents).

(*II*) *Benzal-bis-cyclohexane-spiro-cyclohexane-3:5-dione.*

A mixture of benzaldehyde (2 g.), cyclohexanespiro-cyclohexane-3:5 dione (3·5 g), dry benzene (25 c.c.) and piperidine (4 drops) was kept at the ordinary temperature for 12 hours. The residue left after removing benzene under suction, was crystallised from dilute alcohol when lustrous needles melting at 132-133° were obtained. Its alcoholic solution gave red colouration with ferric chloride solution. (found C, 77·6 : H, 8·1 ; $C_{29}H_{36}O_4$ requires C, 77·7 ; H, 8·0 percents).

2-Spiro-cyclohexane-4:5-diketo-7-spiro-cyclohexane-9-phenyl-octahydroxanthene (IV). When the above compound (1·6g.) was heated with acetic anhydride (5 c.c.) on a free flame for 10-15 minutes, and the excess of the anhydride decomposed with water, a solid was precipitated. When crystallised from alcohol, the *octahydroxanthene* derivative was obtained in flat, prismatic needles, melting at 188-189°. This substance did not give any colouration with ferric chloride and was insoluble in Sodium Carbonate solution (found C, 80·6 ; H, 8·1 ; $C_{29} H_{34} O_3$ requires C, 80·9 ; H, 7·9 ; percents).

Salical-bis-cyclohexane-spiro-cyclohexane-3:5-dione (111). A mixture of salicyl-aldehyde (2 g), cyclohexane-spiro-cyclohexane 3:5-dione (3·5g.), dry benzene (20 c.c.) and piperidine (4 to 5 drops) was left at the room temperature for 12 hours. The benzene was removed at the pump, and the solid crystallised from dilute alcohol, when white needles melting at 185° were obtained. It dissolved in Sodium Carbonate solution, and its alcoholic solution gave violet colouration with ferric chloride (found C, 74·9 ; H, 7·62 ; $C_{29} H_{36} O_5$ requires C, 75·0 ; H, 7·76 percents).

2-Spiro-cyclohexane-4: 5-diketo-7-spiro-cyclohexane -9-0- hydroxyphenyl-octahydro-Xanthene (V). The above compound (1gm.) was boiled with glacial acetic acid (15c.c.) for 3-4 hours ; on dilution, white needles melting at 193-194° were obtained. This substance also gave violet colouration with ferric chloride and was soluble in sodium carbonate solution. It was also formed by saturating its absolute alcoholic solution with dry hydrogen chloride, and keeping the mixture overnight (found C, 77.7 ; H, 7.8 ; $C_{29} H_{34} O_4$ requires C, 78·0 H, 7·6 percents).

The acetyl derivative was prepared by heating either the compound (III) or (V) with acetic anhydride for half an hour on a sand-bath. The excess of acetic anhydride was decomposed with water, and the solid crystallised from dilute alcohol, when prismatic needles melting at 183-184° were obtained. It did not give colouration with ferric chloride (found C, 76·1 ; H, 7·6 ; $C_{31} H_{36} O_5$ requires C, 76·2 ; H, 7·5 percents).

Acetylsalical-bis-cyclohexane-spiro-cyclohexane-3:5-dione (VII). A mixture of acetylsalicyl-aldehyde (1·2g.) cyclohexane-spiro-cyclohexane-3:5-dione (1·8g.), dry benzene (10 c.c.) and piperidine (3 to 4 drops) was kept at ordinary temperature for 12 hours. The solid, left after the removal of benzene was crystallised from dilute alcohol, when white needles melting at 190° were obtained. Its alcoholic solution gave brown colouration with ferric chloride solution (found C, 73·4 ; H, 7·7 ; $C_{31} H_{38} O_6$ requires C, 73·5 ; H, 7·5 ; percents).

When this compound was dehydrated by means of acetic anhydride or glacial acetic acid, the resulting product melted at 183–184°,

and was identified as the acetyl derivative of (V), by means of mixed m. p.

2-Spirocyclohexane-4-keto-tetrahydrobenzo-pyranolanhydrochloride (VIII, A). A solution of cyclohexane-spiro-cyclohexane-3:5-dione (1g.), and salicylaldehyde (0·7g.) in methyl alcohol (10 c.c.) was saturated with a rapid current of dry hydrogen chloride at 0°. The solution became dark-red and viscous, and on keeping overnight, deep-red crystals were deposited. These were filtered off, and washed on the filter paper with methyl alcohol saturated with dry hydrogen chloride. The substance did not melt below 300°, and began to decompose on exposure to moist air. It was sparingly soluble in usual organic solvents. The sample for analysis was dried in a vacuum over caustic potash (found C, 71·3 ; H, 6·4; Cl, 11·5, $C_{18}H_{19}O_2Cl$ requires C, 71·4 ; H, 6·28 ; Cl, 11·7 ; percents).

The Anhydrobase was prepared by adding sodium acetate solution to the warm solution of the anhydrochloride in a large excess of ethyl alcohol. The pale pinkish powder that was precipitated was filtered off, and washed alternately with water, alcohol, and ether. Sparingly soluble in almost all the organic solvents, the substance charred at about 300° without melting. The original deep-red colour of the anhydrochloride was restored if it was left in contact with methyl alcohol saturated with dry hydrogen chloride. The anhydrobase was recovered unchanged after heating with a concentrated solution of alcoholic caustic potash (found C, 75·8 ; H, 7·2 ; $C_{18}H_{20}O_3$ requires C, 76·0 ; H, 7·0 percents).

The above work was carried out at the Imperial College of Science and Technology, London, and I express my grateful thanks to Prof. J. F. Thorpe C. B. E., F. R. S., for his kind interest and encouragement, to the Bombay University for the award of a Scholarship, and to the Chemical Society, London, for a grant that partly defrayed the cost.

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NITRIFICATION OF OIL CAKES IN THE TYPICAL SOILS OF THE BOMBAY PRESIDENCY

By

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AND

D. H. GOKHALE, M. Ag.

1. *Introduction.*

Nitrogenous manures are important and their value is usually judged by the percentage of Nitrogen they contain but the real value of such a manure can be judged by the rate at which the nitrogen becomes available to the crop. Nitrogen is generally taken up by plants in the form of nitrates. The rate of nitrification may therefore be taken as a measure to find out the value of a nitrogenous manure. The rate of nitrification depends not merely on the nature of the organic matter but also on the nature of the soil to which the nitrogenous manure is applied. The value of the oil-cakes used as manure depends on the per cent. of nitrogen and also on the rate of nitrification. The latter may vary according to the nature of the soil.

In India nitrification of green manures has been worked by Joshi (1919) and the nitrification of oil-cakes like the Tilli (sesamum orientale), Karanj (Ipomea glabra), Castor Linseed etc., on typical soils of Central Provinces and Berar was worked by Plymen and Bal (1919). They found that the rate of nitrification was different for different oil-cakes and for the same oil-cake it varied with the kind of soil. The object of the work described in this paper was to study the rate of nitrification of some important oil-cakes on the typical and important soils of the Bombay Presidency. The oil-cakes selected were the (1) Groundnut cake, (2) Castor cake and (3) Safflower cake and the soils used were the (1) Medium Black soil derived from the trap (Poona District), (2) Laterite soil from the Belgaum District and (3) the Goradu alluvial soil of the Kaira District.

The following figures indicate the nature of the soils,

TABLE No. 1.

	Medium Black soil.	Laterite soil.	Goradu soil.
	%	%	%
Maximum water holding capacity.	48	38	20
Sticky point (Moisture at)	26·4	16·7	6·4
Retentive portion.	66	49	28
Nonretentive portion.	34	51	72
Capillarity rise in Centimeters.			
3 hours.	2·5	7·5	12·1
3 days.	42·4	59·8	74·5
5 days.	70·1	80·1	80·2
8 days.	106·2	97·5	83·8
Loss on Ignition.	11·49	8·35	4·30
Lime (CaO)	6·15	0·17	1·42

The composition of the oil-cakes used was as follows.

TABLE No. 2.

	Safflower cake. Per cent.	Groundnut cake. Per cent.	Castor cake. Per cent.
Moisture.	9·95	3·62	4·55
	On oven dry matter		
Ether Extract.	4·59	10·53	5·13
*Albuminoids.	32·25	53·57	25·18
Woody fibre.	16·72	4·40	9·54
Other Carbohydrates.	29·21	23·53	49·97
*Containing Nitrogen.	5·16	8·57	4·03

2. *Plan of Experiments.*

In order to ensure even sampling of the oil cakes, a sample of each was passed through a handmill twice before it was taken for experiment. The uniformly ground sample was then sterilized in an Autoclave at 120°C. for an hour and then mixed with the soil.

Three sets for three different soils were arranged each containing five trays filled with 1000 grams of soil which was previously sampled and passed through 1 mm. sieve. Of the five trays the first received 3% Safflower cake, the second received 3% Groundnut cake, the third received 3% Castor cake and the fourth received a sample of 3% fat-

free Groundnut cake for comparative observations and to note if either the presence or absence of the high percentage of oil in the cakes affected the nitrifiability of the cakes. The fifth tray was the Control and received no cake.

Two more similar sets—one for the Laterite and the other for the Goradu soil—were filled up. A thorough mixing up was ensured by a number of nitrogen determinations from each of the trays.

At the start of the experiment moisture equivalent to 50% of the maximum water holding capacity of the respective soils (giving the optimum conditions of moisture) was added and evenly distributed by sampling. The loss of moisture due to normal evaporation was made up twice every week in order to maintain uniform moisture conditions. All trays were kept within a narrow limit of varying temperature namely between 27^0 and 30^0C.

All the samples were analysed every fortnight and the following determinations were made :—

1. Nitrogen in all forms including

(a) Total nitrogen.

(b) Ammoniacal Nitrogen.

(c) Nitrate and Nitrite Nitrogen.

3. *Method of Analysis.*

(a) Total Nitrogen.

20 grams of a sample soil was treated according to the Official Methods of Analysis (1921).

(b) Ammoniacal Nitrogen.

50 grams of the soil sampled was shaken with a solution of Sodium Chloride for half an hour and an aliquot portion of the extract was distilled over Magnesium Oxide and Ammonia was estimated as usual (McLean and Robinson (1924)).

(c) Nitrate and Nitrite Nitrogen.

The Griess Ilosway method for the determinations of nitrites and the Phenol Disulphonic acid method for the determinations of the nitrates were employed. In both cases the standard Tinto-meter glasses were used for matching the developed colour.

It was found that the extracts of the samples with Groundnut cake were turbid on account of the fine suspended matter and the extracts with Safflower cake were coloured yellow. This interfered

with the estimations and therefore the following method suggested by Syme (1909) was used to remove the difficulty :—

About 50 c.c. of the soil extract was heated to about 50° to 60°C. and treated with 1 c.c. of dilute (1 to 5) Sulphuric acid followed by an excess of Potassium permanganate (5 to 10 grams dissolved in a litre) which is added from a burette. The extract is heated for 15 minutes on a water bath, more Potassium permanganate solution being added from time to time if required. The whole is filtered and the filtrate made slightly alkaline with Sodium Carbonate and evaporated to dryness on a water bath. The residue is taken up with water and filtered and the filtrate is made up to 50 c.c. and the Nitrates estimated as usual. In such a case the nitrites originally present turned into nitrates.

4. *Nitrogen Changes of Oil Cakes in Soils.*

Of all the chemical changes that take place during the process of nitrification of the nitrogenous organic matter in the soil, ammonification marks a very definite and readily perceptible change. The estimation of ammoniacal nitrogen of the samples at regular intervals of time would give a fair idea with regard to the comparative rates of decomposition of the samples of oil-cakes used in the experiment. The three different sets with the three different soils have given appreciably different results and therefore it is proposed to examine them separately.

In all 8 determinations at regular stages were made including the observations at the start and extending over a period of 100 days.

(*a*) *Medium Black Soil.*

TABLE NO. 3.

Milligrams of ammoniacal nitrogen per 100 grams of oven dry soil.

Time.	Groundnut Cake. Ordinary.	Groundnut Cake. Fat-Free.	Safflower. Cake.	Castor Cake.	Control
0 days.	0·51	0·53	Trace.	Trace.	Trace.
14 days.	6·12	5·86	2·70	2·41	0·45
28 days.	11·19	10·38	5·00	4·54	0·94
42 days.	16·40	15·34	8·08	7·28	1·24
56 days.	28·23	26·21	12·45	11·60	1·64
70 days.	49·72	37·56	18·26	16·31	1·59
84 days.	71·39	47·13	21·91	22·18	1·62
100 days.	92·21	64·35	26·65	27·40	1·51

The figures presented in the above table show clearly enough the different degrees of ammonification in the different samples of oil cakes used. Taking the Groundnut cake, we find the ammoniacal nitrogen content of the sample is increased day after day until at the end of 100 days, 92 milligrams of ammoniacal nitrogen is found per 100 grams of oven dry soil. If we examine the figures for all different stages at which the samples were analysed it can be seen that there is a gradual rise in the ammoniacal nitrogen contents throughout.

In the case of the fat-free Groundnut cake the ammonification is appreciably lower than the ordinary cake. This suggests that either the removing of fat results in the lowering of the rate of decomposition or that the extraction of the fat by Ether might have affected an anti-biotic condition if ammonification is regarded as a bio-chemical change. Playmen and Bal (1919) have not found the fat-free Tili cake inferior to the ordinary cake in their experiments where they seem to have made a comparative study of the ordinary Tili cake and the fat-free Tili cake as has been done in the case of Groundnut cake in these experiments. The comparative study made here suggests that the process of ammonification is not a purely chemical process. If it were so there should not have been so much difference in the ammonifiability of the ordinary Groundnut cake and the fat-free Groundnut cake because these two samples are under precisely identical conditions otherwise. Taking also the view that ammonification is an auto-catalytic change we find that both the samples had a fairly equal start and the differences brought about in the later stages were due to other non-chemical influences. There is a very important suggestion made by Subramhanyan (1925) that ammonification is an enzyme action. It is quite probable from this point of view that the enzymes present in the Groundnut cake were either destroyed in the process of extraction by Ether or were extracted along with the fat.

Considering next the figures obtained in the case of the Safflower cake and the Castor cake it can be seen that both of them are slow and compete closely in the extent of decomposition. The Safflower cake is richer in nitrogen content by 1% than the Castor cake but is slightly slower in ammonification because it contains 16% woody fibre as against 9% in the Castor cake (Table No. 1). The Groundnut cake of course contains the lowest amount of woody fibre being only 4% which also speaks in favour of its rapid decomposition.

In presenting the nitrification figures they are given as nitrogen nitrified per 100 grammes of the original total nitrogen present in the various samples, because these figures would be easily comparable although the percent of nitrogen may be different in different oil-cakes.

TABLE No. 4.

(Nitrification of various oil cakes.)

Nitrified nitrogen per 100 grammes of the total nitrogen present.

Time.	Groundnut Cake. Ordinary.	Groundnut cake. Fat-free.	Safflower cake.	Castor cake.	Control
0 days.	0·55	0·52	0·43	0·46	0·50
14 days.	2·42	1·74	2·10	2·14	1·12
28 days.	5·13	3·96	4·35	4·98	1·54
42 days.	9·44	6·72	6·38	8·08	2·13
56 days.	17·26	10·52	8·62	11·44	2·83
70 days.	25·52	16·81	12·10	16·28	3·21
84 days.	33·64	27·20	16·22	20·24	3·22
100 days.	41·82	34·40	20·10	24·33	3·19

A glance at Table No. 3 shows the different degrees of nitrification of the different oil cakes. They stand just in the same order as they stood in the ammonification process and therefore there are reasons to suppose that there is some inter-depending connection between ammonification and nitrification although Lipham and Burges (1917) say that :—

" The ammonifiability data of fertiliser nitrogen in soils are not useful indication of nitrifiability data on the same fertiliser and on the same soil."

Thus 41% of the total nitrogen in the ordinary Groundnut cake is nitrified in a period of 100 days while only 34% of the total nitrogen in the fat-free Groundnut cake is oxidised within the same period. Even if the Blanks which are common to all the samples are deducted the comparative value remains the same. It is again indicated here that either the extraction of oil cake or the method of extraction inhibits the process of nitrification.

The Safflower cake is as slow in nitrification as it was in the ammonification and only 20% of its total nitrogen is nitrified. The Castor cake nitrifies to the extent of 24% and therefore supplies a little more available nitrogen than the Safflower cake.

(*b*) ***Laterite Soil.***

The same samples of oil cakes show a marked difference both in ammonification and nitrification in the Laterite soil. The following table makes this clear.

TABLE No. 5.

Ammonification of various oil cakes in the Laterite soil.
Milligrams of ammoniacal nitrogen per 100 grams of oven dry soil.

Time.	Groundnut Cake. Ordinary.	Groundnut Cake. Fat-free.	Safflower Cake.	Castor Cake.	Control
0 days.	0·49	0·51	Trace	Trace	Trace.
14 days.	2·31	1·88	0·86	0·66	Trace.
28 days.	8·86	6·54	2·46	2·23	0·29
42 days.	15·54	12·18	5·17	4·87	0·40
56 days.	24·28	18·30	7·79	7·63	0·38
70 days.	33·16	23·82	10·11	10·42	0·37
84 days.	41·82	29·04	13·26	14·80	0·44
100 days.	49·45	34·70	15·40	17·40	0·36

Here the ammonifiability is far lower than that obtained in the Medium Black soil. This is another reason to support the view that the process of ammonification is neither purely chemical nor is it purely an enzymic action. If it were purely a chemical one the same condition of moisture and time would have given the same amount of ammonification even in this soil. Even if it were an enzymic action, all the samples except the fat-free Groundnut cake had the enzymes safe and they would act in this soil as well. These observations do hint that the soil exerts a very considerable influence on the ammonification as well as nitrification and this influence is in all probability a bio-chemical one.

The general figures in the above table leave no doubt that the Laterite soil is biologically very poor or at least poorer than the Medium Black soil.

Even in the case of nitrification the figures in this soil are very low and the samples stand in the same order as in the case of ammonification.

TABLE No. 6.

Nitrification of various oil cakes in the Laterite soil.
Percent of nitrified nitrogen of the total nitrogen present.

Time.	Groundnut Cake. Ordinary.	Groundnut Cake. Fat-free.	Safflower Cake.	Castor Cake.	Control.
0 days.	0·45	0·31	0·21	0·38	0·23
14 days.	1·83	2·01	1·58	1·67	0·27
28 days.	4·54	4·77	2·86	3·06	0·26
42 days.	8·22	8·87	5·19	5·48	0·28
56 days.	13·76	12·79	8·80	8·93	0·36
70 days.	19·04	16·81	13·09	13·42	0·31
84 days.	24·39	20·95	16·56	17·02	0·28
100 days.	29·57	25·65	18·96	20·40	0·28

The ordinary Groundnut cake nitrifies only to the extent of 29% of its total nitrogen, while the fat-free Groundnut cake nitrifies to the extent of 25%. The corresponding nitrification figures in the Medium Black soil are 41% and 34% respectively, showing a large drop in nitrification. The Safflower cake and the Castor cake are close to each other as in the Medium Black soil, the Castor cake being slightly better than the Safflower cake. The woody fibre in the Safflower cake is clearly a handicap in its nitrification.

(c) *Goradu Soil.*

The same oil cakes added to the Goradu soil showed interesting results. The Goradu soil is distinctly superior to the Laterite soil although it stands below the Medium Black soil. The idea that the lime content of the soil and its biological activity has some correlation gains support from these results. The lime percent in Goradu soil is double that of Laterite soil. The following table presents figures on the ammonification of oil cakes.

TABLE NO. 7.

(Ammonification of various oil cakes in the Goradu soil).

Milligrams of ammoniacal nitrogen per 100 grams of oven dry soil.

Time.	Groundnut cake. Ordinary.	Groundnut cake. Fat-free.	Safflower cake.	Castor cake.	Control.
0 days.	0·32	0·31	Trace	Trace	Trace
14 days.	3·18	1·83	0·82	0·54	0·34
28 days.	7·41	4·71	1·43	1·03	0·42
42 days.	14·36	9·36	4·56	3·23	0·51
56 days.	23·53	14·52	8·89	5·16	0·52
70 days.	36·19	24·41	14·38	11·20	0·49
84 days.	47·45	32·12	18·92	16·28	0·43
100 days.	58·26	40·80	24·14	19·82	0·36

The ammonification is fairly rapid in this soil though by no means equal to that in the Medium Black soil. The fat free Groundnut cake is found to be distinctly inferior material throughout the experiments with all the types of soil. The only point of importance here is that the Safflower cake is better than the Castor cake in this soil in spite of its high woody fibre content.

A comparative table for all the soils showing the extent of ammonification after 100 days gives a better idea.

TABLE No. 8

(Comparative study of ammonification of various oil cakes in the three different soils.)

Milligrams of ammoniacal nitrogen per 100 grams of oven dry soil.

Time	Groundnut cake. Ordinary.	Groundnut cake. Fat-free.	Safflower cake.	Castor coke.	Control.
The Medium Black Soil.					
100 days.	92·21	64·35	26·65	27·40	1·51
The Laterite Soil.					
100 days.	49·45	34·71	15·40	17·40	0·36
The Goradu Soil.					
100 days.	58·26	40·80	24·14	19·82	0·36

The figures on nitrification are also interesting because they prove the superiority of the Goradu soil over the Laterite soil. The Safflower cake is more suitable than the Castor cake for the Goradu soil is again confirmed by the figures on the nitrification as under :—

TABLE No. 9

(Nitrification of various oil cakes in the Goradu soil.)

Percent of nitrified nitrogen of the total nitrogen present.

Soil and Time.	Groundnut cake. Ordinary.	Groundnut cake. Fat-free.	Safflower cake.	Castor cake.	Control.
0 days.	0·32	0·41	Trace	Trace	Trace
14 days.	1·40	1·24	0·72	0·38	0·26
28 days.	3·68	2·93	1·62	1·38	0·38
42 days.	8·29	6·83	3·46	2·53	0·41
56 days.	14·13	12·54	6·29	5·18	0·47
70 days.	20·75	18·22	12·30	12·62	0·39
84 days.	27·17	24·04	15·82	17·30	0·34
100 days.	32·95	29·82	19·52	17·30	0·36

A comparative table for the nitrification of all the oil cakes after a period of 100 days could be presented as follows :—

TABLE No. 10.

(Comparative study of nitrification of various oil cakes in different soils.)

Percentage of total nitrogen nitrified.

Soil.	Groundnut cake. Ordinary.	Groundnut cake. Fat-free.	Safflower cake.	Castor cake.	Control.
The Medium Black.	41·82	34·40	20·10	24·33	3·19
The Laterite	29·57	25·65	18·96	20·40	0·28
The Goradu	32·95	29·82	19·52	17·30	0·36

Thus the study of the nitrification of the different oil cakes in the different soils shows the marked differences in the availability of nitrogen of the various materials added to the soil and at once gives us the idea about the efficiency of the material added as manure. This also clearly shows that merely a high percentage of nitrogen in a substance does not mean much if the rate of its availability is not known. Similarly the experiments show also the marked difference in the soils, and suggest that the biological activity of the soils is perhaps a more important factor than the physical and the chemical properties.

5. The results so far examined could be summarised as follows :—

1. The Groundnut cake is the most easily nitrifiable material of the oil cakes used in the experiments.

2. The fat-free Groundnut cake is distinctly inferior in nitrification than the ordinary Groundnut cake.

3. The Safflower cake and the Castor cake compete very closely and if a comparison has to be made, the Castor cake nitrifies better than the Safflower cake in the Medium Black soil and the Laterite soil while the Safflower cake stands better in the Goradu soil.

4. Ammonification and nitrification show a close relation.

5. Of the soils examined the Medium Black soil is the most active. The Goradu soil comes next and the Laterite soil stands last.

6. *The Loss of Nitrogen.*

Although under an anaerobic conditions there is no loss of nitrogen during the process of decomposition according to Subramahanyan (1927) we find that this is by no means the case under aerobic conditions. Joshi (1919) observed such a loss during the study of biochemical decomposition of Cowdung and Urine, and remarked :—

" Under aerobic conditions there was loss in all cases but as the figures for the loss of moisture under these conditions were not accurately determined before hand no opinion can be expressed as to the relative loss of nitrogen from each of the materials."

But at another place the same worker remarks that he did not find any loss of nitrogen in the decomposition of organic matter.

A remarkable loss of nitrogen has been found during the experiments on the nitrification of oil cakes so far examined. The loss varied with the nature of the oil cakes as well as with the nature of the soil. The following table gives the figures of total nitrogen as obtained at various stages of nitrification in the Medium Black soil :—

TABLE No. 11.

The total nitrogen of various oil cakes at different stages of nitrification.

Milligrams per 100 grams of oven dry soil.

Days.	Groundnut cake. Ordinary.	Groundnut cake. Fat-free.	Safflower cake.	Castor cake.	Control.
0 days.	413	443	314	280	169
14 days.	412	443	315	278	169
28 days.	413	440	313	279	168
42 days.	409	441	312	276	168
56 days.	408	440	310	273	168
70 days.	402	438	310	273	168
84 days.	382	436	308	271	167
100 days.	364	434	304	269	167
Net Loss.	49	9	10	11	2

The loss of nitrogen in the ordinary Groundnut cake sample is the greatest. As many as 48 milligrams are lost in a period of 100 days. Other oil cakes lose comparatively small quantities. Thus the Safflower cake loses only 10 milligrams and the Castor cake 11 milligrams durring the same period. The control loses only 2 milligrams. The fat-free Groundnut cake shows particulary interesting results inasmuch as it loses only 9 milligrams showing the smallest loss. The reason for the loss of total nitrogen is probably the process of denitrification that always goes on in the soil when nitrates accumulate to a certain limit as explained by Warrington (1892). If denitrification is also a bio-chemical change, the removal of oil from the Groundnut cake retards this activity also.

The loss of nitrogen is different with different soils. The lighter the soil the greater the loss. The following table gives the total nitrogen as obtained in the Laterite soil at various stages :—

TABLE NO. 12.

The total nitrogen of various oil cakes at different stages of nitrification in the Laterite soil.

Milligrams per 100 grams of oven dry soil.

Days.	Groundnut cake. Ordinary.	Groundnut cake. Fat-free.	Safflower cake.	Castor cake.	Control.
0 days.	358	388	284	224	117
14 days.	358	388	285	225	118
28 days.	351	386	285	225	117
42 days.	356	387	284	224	117
56 days.	342	384	282	220	116
70 days.	338	378	279	216	117
84 days.	321	374	274	215	116
100 days.	303	373	272	215	116
Net loss	55	15	12	9	1

The increased loss in the Groundnut cakes amples is conspicuous in the Laterite soil. The other samples do not show much difference as compared to the Medium Black soil.

The figures for total nitrogen in the Goradu soil confirm the observation made above. The figures are presented in the following table :—

TABLE NO. 13.

The total nitrogen of various oil cakes at different stages of nitrification in the Goradu soil.

Milligrams per 100 grams of oven dry soil.

Days.	Groundnut cake. Ordinary.	Groundnut cake. Fat-free.	Safflower cake.	Castor cake.	Control.
0 days.	290	320	180	158	48
14 days.	290	320	181	158	48
28 days.	289	319	181	156	47
42 days.	285	318	178	157	48
56 days.	278	316	179	154	47
70 days.	268	308	178	154	46
84 days.	252	302	176	150	46
100 days.	225	300	174	150	46
Net loss.	65	20	6	8	2

A comparative study of the different soils and different samples of oil cakes will give a clear idea for which the following table will be useful :—

TABLE NO. 14.

(A comparative study of the loss of nitrogen in different soils with different oil cakes.)

Milligrams of total nitrogen lost per 100 grams of oven dry soil in a period of 100 days.

Soil.	Groundnut cake. Ordinary.	Groundnut cake. Fat-free.	Safflower cake.	Castor cake.	Control.
The Medium Black.	48	9	10	11	2
The Laterite.	55	15	12	9	1
The Goradu.	65	20	6	8	2

Thus the loss of nitrogen in the Groundnut cake is found to be the greatest in all the soils. If soils are compared, the Goradu soil loses comparatively more nitrogen than the Medium Black and the Laterite soils.

The loss is chiefly found to be considerable when large quantities of nitric nitrogen begin to accumulate.

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ACTION OF ACETIC ANHYDRIDE AND SODIUM ACETATE ON THE ANHYDRIDES OF β-ARYL-GLUTACONIC ACIDS :—
FORMATION OF GLUTACONYL-ACETIC ACIDS.

By

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Introduction :—

Based on an earlier observation by one of us a simple method has been developed in this laboratory of preparing a number of β-aryl-glutaconic acids and the formation of the corresponding anhydride in a typical case of β-(4-methoxy-phenyl)-glutaconic acid has been described in the Journal of the Indian Chemical Society *1931*, 8,139. This anhydride titrates with alkali as a monobasic acid and gives a colouration with ferric chloride. In order to account for similar properties of the substituted glutaconic anhydrides studied by Thorpe and Collaborators, an hydroxy anhydride structure, as distinguished from the " normal," has been suggested by them and acetyl derivatives have been prepared by the action of acetyl chloride on the OH group in some of the cases (J. Chem. Soc. *1911*, 99, 2187 ; *1912*, 101, 858). With a view to prepare a similar neutral acetyl derivative the action of acetic anhydride was first tried on the β—(4-methoxy-phenyl)-glutaconic anhydride. It was soon observed however that acetic anhydride alone had no action, but that in the presence of fused sodium acetate products were obtained which proved to be different from the expected neutral acetyl derivative. Further investigation has led to the discovery of glutaconyl-acetic acids and related compounds, which form the subject of the present communication.

Theoretical :—

The product obtained from β-(4-methoxy-phenyl)–glutaconic acid by the action of acetic anhydride and sodium acetate under conditions described in the experimental part, melted between 115° to 125°C and was obviously a mixture. Three substances were ultimately separated from this : an acid M.P. 132°C forming the main product ; a neutral product M.P. 112°C and a ketonic acid M.P. 125°C. Out of these only the acid M.P. 132° gave a colouration with ferric chloride. The substance M. P. 112° resulted from the acid M.P. 132° by the loss of one molecule of CO_2. It thus became clear that, the nature of the reaction was not that of the acetylation of the colour giving OH of the anhydride of the glutaconic acid.

A closer study of the properties of the three substances revealed the following inter-relation :—

Acid M.P. 132°			Substance M.P. 112°
$C_{14}H_{12}O_5$	$-CO_2$	$\rightarrow$	$C_{13}H_{12}O_3$
Eq. wt. 260	-44	$\rightarrow$	Mol. wt. 216

$\downarrow$ $+H_2O-CO_2$ $\qquad$ $-H_2O \nearrow$ $\qquad$ $\swarrow +H_2O$

Acid M.P. 125° (Ketonic)
$C_{13}H_{14}O_4$
Eqt. wt. 234

This indicated that the acid M.P. 132° was the primary product of the reaction and the other two substances were by-products. It appeared probable that the substance M.P. 112° was a lactone of the ketonic acid M.P. 125° and that the substance M.P. 132° was a lactonic acid. It was therefore decided to determine the structure of the ketonic acid M.P. 125° first.

When heated above its melting point the ketonic acid gave a neutral ketone $C_{12}H_{14}O_2$ M. P. 48°, by loss of CO_2. This ketone on oxidation with chromic acid gave anisic acid, a fact which did not throw much light on the constitution. However when oxidised by Iodine in alkaline solution an acid $C_{11}H_{12}O_3$ M. P. 155° was obtained which was identified as paramethoxy-β-methyl-cinnamic acid. This fixed the structure of the ketone M. P. 48° as (4-methoxy-α-methyl) benzylideneacetone or in other words—α-acetonyl-α-(4-methoxy-phenyl)-ethane.

$$CH_3O.\ C_6H_4.\underset{\displaystyle CH_3}{\underset{|}{C}}=CH.CO.\ CH_3 \quad (1)$$

The oxidation reaction is similar to that of benzylideneacetone to cinnamic acid by alkaline hypochlorite.

The structure of the Ketonic acid M.P. 125° could now be represented as

$$CH_3O.\ C_6H_4.\ C\negthinspace\begin{array}{l}\nearrow CH.\ CO.\ CH_3\\ \searrow CH_2.\ COOH\end{array} \quad (II)$$

The alternative structure $CH_3O.\ C_6H_4C\negthinspace\begin{array}{l}\nearrow CH.\ CO.\ CH_2.\ COOH\\ \searrow CH_3\end{array}$

was set aside as the properties of the acid did not accord with those of a β-Ketonic acid and the formation of a lactone, not containing a carbonyl group could not be explained. Moreover the structure of the keto acid is confirmed, as on reduction it passes into β-(4-methoxy-phenyl)-γ-aceto-butyric acid which is a known substance.

$$CH_3O.\ C_6H_4.\ CH{<}\begin{matrix} CH_2.\ CO.\ CH_3 \\ CH_2.\ COOH. \end{matrix} \qquad (III)$$

Hence the action of acetic anhydride and sodium acetate on β-(4-methoxy-phenyl)-glutaconic anhydride can be represented as,

$$CH_3O.\ C_6H_4.\ C{<}\begin{matrix} CH.\ CO \\ CH=COH \end{matrix}{>}O \ + CH_3.\ COOH\ (Na) = H_2O +$$

β-(4-Methoxy-phenyl)-glutaconic anhydride (hydroxy form) (IV)

$$CH_3O.\ C_6H_4.\ C{<}\begin{matrix} CH.\ C=CH.\ COOH\ (Na) \\ {>}O \\ CH=COH \end{matrix}$$

β-(4-Methoxy-phenyl)-glutaconyl-acetic acid (V)

The glutaconyl-acetic acid then gives, by decarboxylation the neutral substance M. P. 112°

$$CH_3O.\ C_6H_4.\ C{<}\begin{matrix} CH.\ C=CH_2 \\ CH_2.\ CO \end{matrix}{>}O$$

β-(4-Methoxy-phenyl)-methylene glutaconide (VI)

The corresponding 'Normal' or 'keto' form of the glutaconyl-acetic acid has also been isolated. Regarding this as also the effect of conjugation on the course of the reaction, will be reported in a future communication.

The reaction has been extended to five other glutaconic anhydrides.

It will be seen that the reaction resembles Perkin's reaction for unsaturated acids of the cinnamic type or to be more correct the Gabriel's extention of Perkin's reaction to phthalic anhydride (Berichte *1893*, 26, 952; *1896*, *29*, 2518). The parallelism is so close that it can be followed through almost the entire series of related compounds viz.

	(1)	(2)	(3)
(a)	Phthalic anhydride.	Phthalyl-acetic acid.	Methylene phthalide.
(b)	Glutaconic anhydride	Glutaconyl-acetic acid.	Methylene-glutaconide.
	(4)	(5)	(6)
(a)	Dibasic β Ketonic acid.	Acetophenone ortho-carboxylic acid.	Acetophenone.
(b)	Unstable β ketonic disbasic acid (not isolated).	β-4-Methoxy-phenyl-γ-aceto-vinylacetic acid.	Methylbenzylidene acetone.

Experimental :—

(1) *Isolation of the three products* formed by the action of acetic anhydride and sodium acetate on β-(4-methoxy-phenyl)-glutaconic anhydride. (IV)

As the β-aryl-glutaconic acids are readily converted into the anhydrides by the action of acetic anhydride, it was found possible to use the acids themselves as starting material, provided sufficient acetic anhydride was used for the reaction.

A mixture of 5 grms. of β-(4-methoxy-phenyl)-glutaconic acid. 5 grms. of fused sodium acetate and 7.5 c.c. of acetic anhydride is heated at the temperature of boiling water bath for 7 to 10 minutes. The resulting red liquid is poured in 100 c.c. of water, stirred and allowed to stand for two hours. A brittle cake separates, it is removed by filtration and on purification yields an acid M. P. 132° (yield 3 grms.). On leaving the filtrate over night a second crop of reddish crystals is obtained, separable by boiling water into an acid M. P. 125° (0. 4 grams) and a neutral substance M. P. 112° (0·3 grm.). The last two substances are more conveniently prepared from the acid M. P. 132°; the following modification serves as a preparative process for the acid M. P. 132°.

(2) β-*(4-Methoxy-phenyl)-glutaconyl-acetic acid M. P. 132°* (V)

After pouring the melt in water as described above about 8 c.c of hydrochloric acid (1.16) are added. The sticky mass that solidifies in about an hour is filtered off and washed. It can be purified by crystallisation from glacial acetic acid or alcohol. Best results are obtained by exactly neutralising with normal caustic soda, filtering and precipitating the filtrate by the addition of 10 normal caustic soda, collecting the sodium salt, washing it with small amounts of water and regenerating the acid by hydrochloric acid, and crystallising it from 75% acetic acid. The acid thus obtained melts at 132° without decomposition. In alcoholic solution the acid gives a strong violet colouration with ferric chloride. It is insoluble in water, sparingly soluble in dilute acetic acid, alcohol, acetone, and benzene, and soluble in ether.

Found	C = 64·5 ;	H = 4·6	Equivalent = 261
$C_{14}H_{12}O_5$ requires	C = 64·6 ;	H = 4·6	„ = 260

It gives paramethoxy acetophenone on boiling with 15% caustic alkali.

(3) β-*(4-Methoxy-phenyl)-γ-aceto-vinylacetic acid* (II)

A clear solution of the glutaconyl acetic acid M. P. 132° 5 grms. dissolved in 125 c.c. normal caustic alkali is allowed to stand over night and then warmed on water bath for half an hour, cooled, extracted with ether to remove some oily impurities and acidified with dilute

hydrochloric acid, keeping the solution cool. The solid that separates is somewhat sticky and its purification requires care. It is first crystallised from 75% acetic acid and then from hot water avoiding long boiling. The perfectly white crystals melt at 125° with decomposition.

Found $C = 66{\cdot}3$; $H = 6{\cdot}15$ % Equivalent = 233
$C_{13}H_{14}O_4$ requires $C = 66{\cdot}6$; $H = 6{\cdot}0$ % Equivalent = 234

The acid gives no colouration with ferric chloride. It is soluble in ether, benzene, chloroform acetone and alcohol, and sparingly soluble in acetic acid and water.

The semicarbazone of the acid melts at 155° with decomposition and titrates as a monobasic acid. Found equivalent 293. $C_{14}H_{17}O_4N_3$ requires equivalent 291.

The Phenyl hydrazone of the acid melts at 165° with decomposition. Found equivalent 325. $C_{19}H_{20}O_3N_2$ requires equivalent 324.

The Oxime melts at 190° with decomposition.

The ethyl and methyl esters of the acid cannot be prepared by the Fischer-Spier method as the formation of the lactone M. P. 112° is favoured. The same can however be prepared through the silver salt by the action of alkyl iodides, but cannot be purified, as even distillation in vacuum gives the lactone.

(4) *β(4-Methoxy-phenyl)-methylene glutaconide* (VI)

This lactone of β-(4-methoxy-phenyl)-γ-aceto-vinylacetic acid can be obtained as described in Exp. 1; or by the action of acetic anhydride on the ketonic acid. It is best prepared by heating 5 grms. of the glutaconyl-acetic acid with 10 c.c. of 30% hydrochloric acid over a sand bath for 2 hours and pouring the resulting solution in water. The solid that separates is filtered off, treated with cold dilute alkali, filtered, washed with water, and finally crystallised from alcohol. The beautiful plates with pearly lustre melt at 112° yield 2. 3 grms.

Found $C = 72.0$; $H = 5.7\%$
$C_{13}H_{12}O_3$ requires $C = 72.2$; $H = 5.6\%$

It gives no colouration with ferric chloride. It is insoluble in water and dilute acetic acid, sparingly soluble in alcohol, glacial acetic acid and benzene, and soluble in ether and chloroform. On hydrolysis with alkali it gives the δ-Keto acid M.P. 125°. It does not react with ketonic reagents.

(5) *(4-Methoxy-α-methyl-benzylidene)-acetone* (I)

The acid M.P. 125° (Exp.3) is heated above its melting point till the evolution of CO_2 ceases and then distilled under reduced pressure,

A liquid passes over at 145° at 5 m.m. pressure. It is purified by redistillation when a neutral solid M.P. 48°, is obtained.

Found	C = 75·5 ; H. = 7·6%
$C_{12}H_{14}O_2$ requires	C = 75·8 ; H = 7·3%

The Semicarbazone M.P. 193°

Found	C = 63.3 ; H = 6.8%
$C_{13}H_{17}O_2N_3$ requires	C = 63.2 ; H = 6.9%

The Phenylhydrazone M.P. 70°. *The Oxime* M.P. 107°

Oxidation of the Ketone :—A mixture of 2 grms. of the ketone M.P. 48° and 25 c.c. of 4 normal caustic alkali is shaken for an hour with the addition of 9 grms. of Iodine, allowed to stand for 3 hours, treated with sodium sulphite, acidified and left over night. The crystals that separate, on purification, melt at 154° to 155°.

Found	C = 68.8 ; H = 6.1%; Equivalent = 192
$C_{11}H_{12}O_3$ requires	C = 68.76 ; H = 6.25% ; „ = 192

This acid was identified as paramethoxy-β-methyl-cinnamic acid by mixed melting point with the known compound and by its conversion into the known paramethoxy-iso-propylene benzene.

(6) β-*(4-Methoxy-phenyl)*-γ-*aceto butyric acid* (III)

β-(4-Methoxy-phenyl)-γ-aceto-vinylacetic acid (10 grms.) is neutralised with dilute caustic soda and reduced with the slow addition of 100 grms. of 4 % sodium amalgam. After 2 hours the solution is filtered, acidified and the separated acid purified by crystallisation first from water and then from dilute acetic acid. The acid melts at 104° and can be distilled under reduced pressure.

Found	C = 66. 0; H = 6. 6% Equi. = 235
$C_{13}H_{16}O_4$ requires	C = 66. 1 ; H = 6. 8% „ = 236

The acid was identified as the known β-(4-methoxy-phenyl)-γ-aceto-butyric acid by preparing the semicarbazone M. P. 190°, the Oxime M. P. 169° (Vorlander, Annalen *1896*, 294, 253,) and the ethyl ester B. P. at 5 m.m. 190° to 195°, which in turn was converted by sodium ethoxide into anisyl dihydro resorcin a known compound (Vorlander, l. c.).

The reaction has been extended to five other β-Aryl-glutaconic acids and the various products obtained by similar methods resemble in properties with corresponding compounds described above. They are assembled in the following table.

S. No.	Substance	B. P. M. P. °C	Formula	Analysis found	Analysis required
	β-Aryl-glutaconyl-acetic acids				
1.	4-Methoxy-3-methyl-phenyl-	M. P. 189	$C_{15}H_{14}O_5$	C=65·5; H=5·0	C=65·7; H=5·1 %
2.	2-Methoxy-5-methyl-phenyl-	M. P. 129	$C_{15}H_{14}O_5$	C=65·5; H=4·9	C=65·7; H=5·1 %
3.	Phenyl-	M. P. 115	$C_{13}H_{10}O_4$	C=67·6; H=4·2	C=67·8; H=5·3 %
4.	2-Methoxy-4-methyl-phenyl-	M. P. 138	$C_{15}H_{14}O_5$	C=65·6; H=5·1	C=65·7; H=5·1 %
5.	2-Methoxy-phenyl-	M. P. 116	$C_{14}H_{12}O_5$	C=64·7; H=4·5	C=64·6; H=4·6 %
	β-Aryl-Υ-acetovinylacetic acids				
6.	4-Methoxy-3-methyl-phenyl-	M. P. 146	$C_{14}H_{16}O_4$	C=67·5; H=6·4	C=67·7; H=6·5 %
7.	Semicarbazone of (6)	M. P. 155	$C_{15}H_{19}O_4N_3$	Equivalent 303	Equivalent 305
8.	Phenyl-hydrazone of (6)	M. P. 165	$C_{20}H_{22}O_3N_2$	Equivalent 337	Equivalent 338
9.	2-Methoxy-5-methyl-phenyl-	M. P. 98	$C_{14}H_{16}O_4$	C=67·5; H=6·4	C=67·7; H=6·5 %
10.	Semicarbazone of (9)	M. P. 152	$C_{15}H_{19}O_4N_3$	Equivalent 303	Equivalent 305
11.	Phenylhydrazone of (9)	M. P. 122			
12.	Phenyl-	M. P. 109	$C_{12}H_{12}O_3$	C=70·5; H=5·7	C=70·6; H=5·9 %
13.	Semicarbazone of (11)	M. P. 152	$C_{13}H_{15}O_3N_3$	Equivalent 259	Equivalent 261
14.	Phenyl hydrazone of (11)	M. P. 145	$C_{18}H_{18}O_2N_2$	Equivalent 292	Equivalent 294
	β-Aryl-Υ-aceto-butyric-acids				
15.	4-Methoxy-3-methyl-phenyl-	M. P. 72	$C_{14}H_{18}O_4$	C=67·1; H=7·0	C=67·2; H=7·2 %
16.	Semicarbazone of (15)	M. P. 178	$C_{15}H_{21}O_4N_3$	Equivalent 308	Equivalent 307
17.	2-Methoxy-5-methyl-phenyl-	M. P. 98	$C_{14}H_{18}O_4$	C=67·0; H=7·1	C=67·2; H=7·2 %
18.	Semicarbazone of (17)	M. P. 199			
19.	Phenyl-	M. P. 85	(Cf. Vorländer, Annalen *1896*, 294,253)		

20.	Semicarbazone of (19)	M. P. 175	$C_{13}H_{17}O_3N_3$	Equivalent 261	Equivalent 263
	R-α-methyl-benzylidene-acetones				
21.	4-Methoxy-3-methyl-	B. P. 145-150 5 mm.	$C_{13}H_{16}O_2$	C = 76·4; H = 7·8	C = 76·5; H = 7·9 %
22.	Semicarbazone of (21)	M. P. 205	$C_{14}H_{19}O_2N_3$	C = 64·2; H = 7·1	C = 64·4; H = 7·3 %
23.	Oxime of (21)	M. P. 100	$C_{13}H_{17}O_2N$	C = 71·2; H = 6·8	C = 71·2; H = 6·9 %
24.	2-Methoxy-5-methyl-	B. P. 135 5 mm.	$C_{13}H_{16}O_2$	C = 76·3; H = 7·7	C = 76·5; H = 7·9 %
25.	Semicarbazone of (24)	M. P. 200			
26.	R = H	B. P. 125 5. mm.	$C_{11}H_{12}O$	C = 65·3; H = 7·5	C = 65·4; H = 7·5 %
27.	Semicarbazone of (26)	M. P. 190			
	β-Aryl-methylene glutaconides				
28.	4-Methoxy-3-methyl-phenyl-	M. P. 95	$C_{14}H_{14}O_3$	C = 73·9; H = 5·8	C = 74·0; H = 6·1 %
29.	Phenyl-	M. P. 96	$C_{12}H_{10}O_2$	C = 77·2; H = 5·3	C = 77·4; H = 5·4 %
30.	4-Methoxy-3-methyl-β-methyl-cinnamic acid	M. P. 145	$C_{12}H_{14}O_3$	Equivalent 206	Equivalent 206

INHIBITIVE POWER OF GELATINE

By

B. N. DESAI and B. M. NAIK.

Bolam and Desai (Trans. Faraday Soc., 24, 50, 1928) have observed that the time required for the appearance of red coloured precipitate from a yellow mixture of $AgNO_3$ and K_2CrO_4 in gelatine decreases and its p_H increases on subjecting it to hydrolysis. This property of preventing the precipitation of insoluble salt has been termed "inhibitive power". Desai and Nabar (Journ. University of Bombay 1, Part II, 28, 1932) have shown that the inhibitive power of gelatine with reference to Ag_2CrO_4 increases on decreasing the p_H of gelatine. Desai and Nabar (Trans. Faraday Soc. 28, 449, 1932; also see Bolam and Mackenzie, ibid, 22, 151, 162, 1926) have further shown that in the yellow coloured mixture Ag_2CrO_4 exists in ionic condition. In the present paper are given the results of the study of precipitation of Ag_2CrO_4, AgI and PbI_2 in gelatine under different conditions.

(*a*) *Preparation of Ag_2CrO_4 in samples of gelatine of different p_H.*

The gelatine used in these experiments contained 1.177% ash and 18% moisture. The inhibitive power was determined in exactly the same manner as before. The p_H of gelatine was determined colourometrically. Samples of gelatine having different p_H were prepared by adding suitable amounts of acetic acid or sodium acetate. Experiments were carried out by using different equivalent amounts of the reactants. The results of these experiments are given in Tables I to VII.

TABLE I.
Total Volume of mixture = 20 c. c.
Concentration of gelatine = 3%.
p_H of gelatine = 4·5.
Column (1) c. c. of gelatine and column (2) Time of inhibition in minutes.

5 c. c. $\frac{N}{100}$ $AgNO_3$+ 5 c. c. $\frac{N}{100}$ K_2CrO_4		6 c. c. of $\frac{N}{100}$ $AgNO_3$+ 6 c. c. $\frac{N}{100}$ K_2CrO_4		7 c. c. $\frac{N}{100}$ $AgNO_3$+ 7 c. c. $\frac{N}{100}$ K_2CrO_4		8 c. c. $\frac{N}{100}$ $AgNO_3$+ 8 c. c. $\frac{N}{100}$ K_2CrO_4		9 c. c. $\frac{N}{100}$ $AgNO_3$+ 9 c. c. $\frac{N}{100}$ K_2CrO_4	
(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
0·6	1	1·0	2	1·4	2	1·9	2	2·4	2
0·7	2	1·1	6	1·5	4	2·0	4	2·6	5
0·8	7	1·2	16	1·6	9	2·1	7	2·8	11
0·9	19	1·3	45	1·7	24	2·2	13	3·0	21
1·0	43	1·4	120	1·8	49 to 50	2·3	23	3·2	40
						2·4	44		

TABLE II.

Total volume of mixture = 20 c. c.

Concentration of gelatine = 3%.

p_H of gelatine = 4·75.

Column (1) c. c. of gelatine and column (2) Time of inhibition in minutes.

4 c. c. $\frac{N}{100}$ $AgNO_3$ + 4 c. c. $\frac{N}{100}$ K_2CrO_4		5 c. c. $\frac{NO}{100}$ $AgNO_3$ + 5 c. c. $\frac{N}{100}$ K_2CrO_4		6 c. c. $\frac{N}{100}$ $AgNO_3$ + 6 c. c. $\frac{N}{100}$ K_2CrO_4		7 c. c. $\frac{N}{100}$ $AgNO_3$ + 7 c. c. $\frac{N}{100}$ K_2CrO_4	
(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
1·0		1·8	1	2·8	1	4·0	2
1·2	3	1·9	2	3·0	3	4·2	3
1·4	10	2.0	3	3·2	6	4·4	5
1·6	24	2·1	6	3·4	13	4·6	9
1·8	50 to 51	2·2	9	3·6	26	4·8	15
		2·3	13	3·8	53	5·0	25
		2·4	21			5·2	39
		2·5	30				

TABLE III.

Total volume of mixture = 20 c. c.

Concentration of gelatine = 3%.

p_H of gelatine = 5·00.

Column (1) c. c. of gelatine and column (2) Time of inhibition in minutes.

4 c. c. $\frac{N}{100}$ AgNO$_3$+ 4 c. c. $\frac{N}{100}$ K$_2$CrO$_4$		5 c. c. $\frac{N}{100}$ AgNO$_3$+ 5 c. c. $\frac{N}{100}$ K$_2$CrO$_4$		6 c. c. $\frac{N}{100}$ AgNO$_3$+ 6 c. c. $\frac{N}{100}$ K$_2$CrO$_4$		7 c. c. $\frac{N}{100}$ AgNO$_3$+ ·7 c. c. $\frac{N}{100}$ K$_2$CrO$_4$	
(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
1·6	2	2·8	1	4·2	1	5·8	1
1·8	4	3·0	2	4·4	2	6·1	2
2·0	8	3·2	4	4·6	3	6·4	4
2·2	13	3·4	6	4·8	5	6·7	6
2·4	23	3·6	11	5·0	7	7·0	10
2·6	35	3·8	17	5·2	10	7·3	16
		4·0	27	5·4	15	7·6	25
		4·2	42	5·6	21	7·9	39
				5·8	27		

TABLE IV.

Total volume of mixture = 20 c. c.

Concentration of gelatine = 3%.

p_H of gelatine = 5·25.

Column (1) c. c. of gelatine and column (2) Time of inhibition in minutes.

4 c. c. $\frac{N}{100}$ $AgNO_3$+ 4 c. c. $\frac{N}{100}$ K_2CrO_4		5 c. c. $\frac{N}{100}$ $AgNO_3$+ 5 c. c. $\frac{N}{100}$ K_2CrO_4		6 c. c. $\frac{N}{100}$ $AgNO_3$+ 6 c. c. $\frac{N}{100}$ K_2CrO_4		7 c. c. $\frac{N}{190}$ $AgNO_3$+ 7 c. c. $\frac{N}{100}$ K_2CrO_4	
(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
1·7	1	3·7	4	5·2	3	7·0	2
2·0	4	4·0	8	5·6	6	7·4	4
2·3	10	4·3	14	6·0	10	7·8	7
2·6	20	4·6	23	6·4	19	8·2	10
2·9	37	4·9	40	6·8	33	8·6	17
3·1	53	5·2	63	7·2	54	9·0	27
				7·6	85 to 87	9·4	43

TABLE V.

Total volume of mixture = 20 c. c.

Concentration of gelatine = 3%.

p_H of gelatine = 5·52 (gelatine as such).

Column (1) c. c. of gelatine and column (2) Time of inhibition in minutes.

4 c. c. $\frac{N}{100}$ $AgNO_3$+ 4 c. c. $\frac{N}{100}$ K_2CrO_4		5 c. c. $\frac{N}{100}$ $AgNO_3$+ 5 c. c. $\frac{N}{100}$ K_2CrO_4		6 c. c. $\frac{N}{100}$ $AgNO_3$+ 6 c. c. $\frac{N}{100}$ K_2CrO_4		7 c. c. $\frac{N}{100}$ $AgNO_3$+ 7 c. c. $\frac{N}{100}$ K_2CrO_4	
(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
1·6	1	3·4	1	5·4	2	7·4	2
1·9	3	3·7	3	5·7	3	7·7	3
2·2	6	4·0	5	6·0	6	8·0	5
2·5	12	4·3	8	6·3	9	8·3	8
2·8	23	4·6	15	6·6	13	8·6	11
3·1	41	4·9	25	6·9	20	8·9	17
		5·2	39	7·2	27	9·3	26
						9·7	42

TABLE VI.

Total Volume of mixture = 20 c. c.

Concentration of gelatine = 3%.

p_H of gelatine = 5·75.

Column (1) c. c. of gelatine and column (2) Time of inhibition in minutes.

4 c. c. $\frac{N}{100}$ $AgNO_3$+ 4 c. c. $\frac{N}{100}$ K_2CrO_4		5 c. c. $\frac{N}{100}$ $AgNO_3$+ 5 c. c. $\frac{N}{100}$ K_2CrO_4		6 c. c. $\frac{N}{100}$ $AgNO_3$+ 6 c. c. $\frac{N}{100}$ K_2CrO_4		7 c. c. $\frac{N}{100}$ $AgNO_3$+ 7 c. c. $\frac{N}{100}$ K_2CrO_4	
(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
2·4	3	4·4	2	6·5	2	9·4	2
2·7	5	4·7	3	6·8	3	9·8	3
3·0	10	5·0	5	7·1	3	10·2	3
3·3	17	5·3	7	7·4	4	10·6	4
3·6	31	5·6	10	7·7	5	11·0	6
3·9	48	5·9	15	8·0	6	11·4	8
		6·2	21	8·3	8	11·8	10
		6·5	29	9·0	15	12·2	13
						12·6	17
						13·0	21

TABLE VII.

Total volume of mixture = 20 c. c.

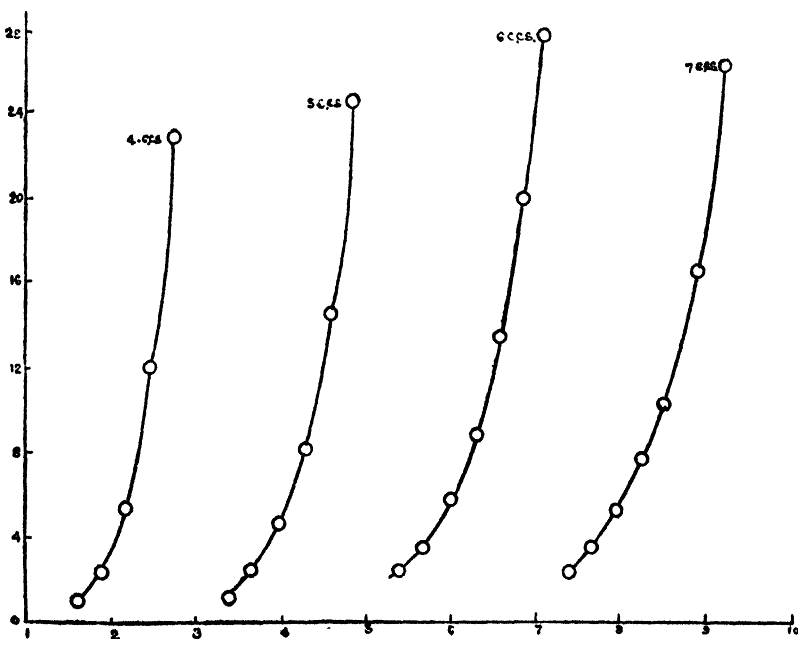
Concentration of gelatine = 3%.

p_H of gelatine = 6·00.

5 c. c. of $\frac{N}{100}$ $AgNO_3$ + 5 c. c. of $\frac{N}{100}$ K_2CrO_4	
c. c. of gelatine.	Time of Inhibition in minutes.
3·8	2
4·1	4
4·4	7
4·7	13
5·0	20

It will appear from the tables that in every case the time of inhibition or the inhibitive power of gelatine increases with an increase in the amount of gelatine added. In Fig. 1 is plotted the amount of

FIG. 1.

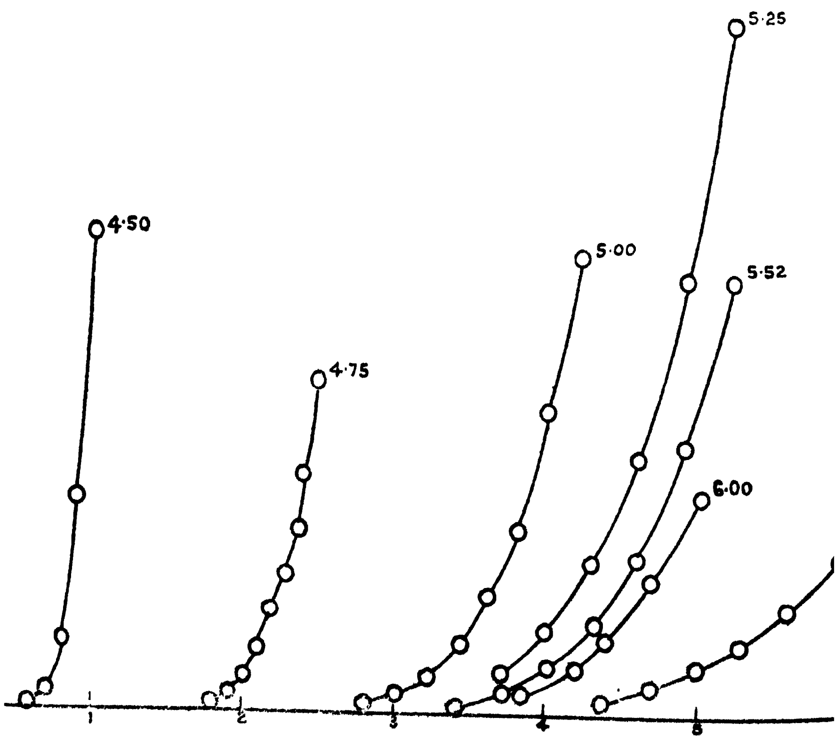


gelatine solution against the time of inhibition for different equivalent amounts of reactants in gelatine having p_H 5.52. It will be seen from the figure that as the amount of the reactants decreases the curve is

displaced more and more towards the Y-axis and that the curves are displaced by almost the same distance for a change in the amount of the reactants by 1 c. c. It would thus appear as if the amount of the reactants whose curve corresponds to the ordinate will approximately give an idea about the solubility of Ag_2CrO_4 in that particular sample of gelatine. The curves for other samples of gelatine are also exactly of the same nature as those given in Fig. 1. The solubility of Ag_2CrO_4 in gelatine of p_H 5.75 calculated on the basis of above ideas comes to about 10 times more than that in water. The solubility of Ag_2CrO_4 in samples of p_H 4·5 and 6·0 comes to about 10% more than that in gelatine of p_H 5·75. It would thus appear that although with slight changes in the p_H of gelatine the inhibitive power changes considerably, the solubility of Ag_2CrO_4 in gelatine is not affected to any appreciable extent by those changes. These results are therefore in line with those obtained by Desai and Nabar (Journ. University of Bombay, loc. cit.).

In Fig. 2 is plotted the amount of gelatine (C) against the time of

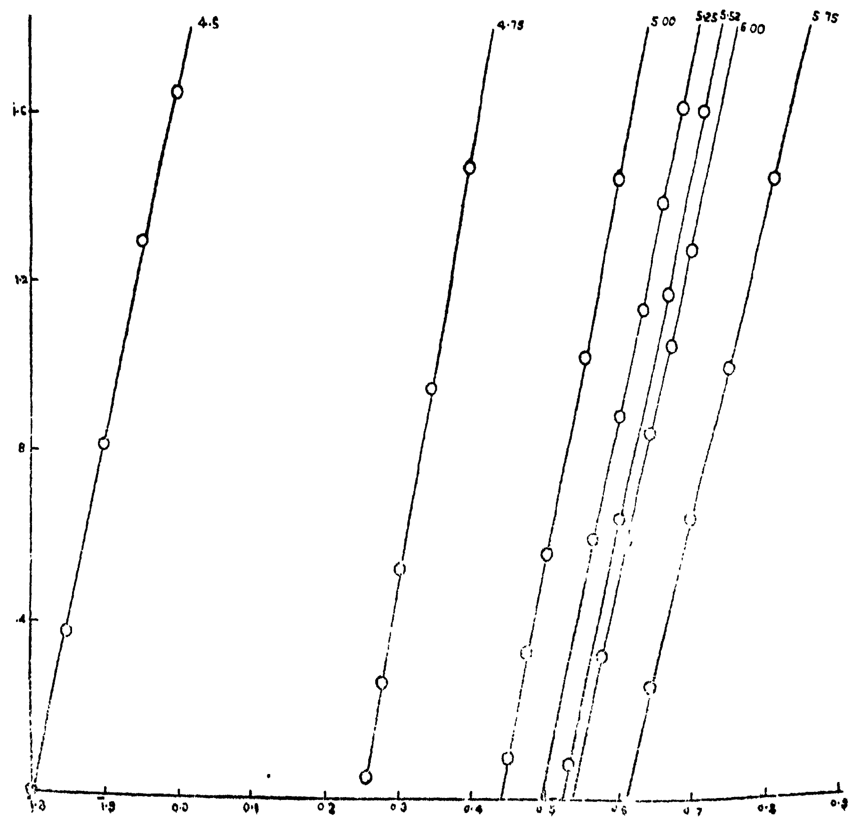
FIG. 2.



inhibition (T) for samples of different p_H in the case of 5 c. c. of $\frac{N}{100}$ $AgNO_3$ + 5 c. c. of $\frac{N}{100}$ K_2CrO_4. It will appear from the figure that the curves for samples of gelatine of p_H either smaller or larger than 5·75 are displaced towards the left of the curve for p_H 5·75. Also as the p_H increases or decreases more and more than 5·75 the curves are displaced more and more towards the ordinate. The curves obtained with different amounts of the reactants show exactly the same behaviour. These results thus show that the inhibitive power of gelatine of p_H 5·75 is minimum and that the inhibitive power of other samples of gelatine of p_H smaller or larger than 5·75 is greater than that of sample of p_H 5·75. These results have a very important bearing on the nature of rings of Ag_2CrO_4 in gelatine for as argued by Desai and Nabar (Journ. Indian Chem. Soc., 9, 141, 1932) there might be a definite range of p_H of gelatine within which good rings can be obtained. This point will however be dealt with in another paper.

In Fig. 3 is given the plot of log C and log T for the same values

FIG. 3



which have been used in Fig. 2. It will appear from this figure that the plot is a straight line and the relation between C and T can be expressed by an equation of the form

$$T = K\,(C)^{m}$$

where K and m are constants. The time of inhibition thus varies exponentially with the amount of gelatine.

In Table VIII are given the results of inhibitive power of gelatine with reference to Ag_2CrO_4 obtained in another manner. In these experiments the amount of Ag_2CrO_4 that can be kept in the mixture for 10 minutes before the appearance of the red colour when 6 c. c. of 3% gelatine solution are added, has been determined.

TABLE VIII.

Total volume of the mixture = 20 c. c.

Concentration of gelatine = 3%.

Amount of gelatine = 6 c. c. in 20 c. c. of mixture.

Time of inhibition (fixed) = 10 minutes.

p_H of gelatine	c. c. of $\frac{N}{100}$ Ag_2CrO_4
4·25	22·0
4·50	12·0
4·75	8·6
5·00	6·8
5·25	6·1
5·52	5·7
5·75	5·3
6·00	5·6
6·25	6·4

It will appear from the results given in the above table that here also gelatine of p_H 5·75 has got the smallest inhibitive power, while samples of gelatine having p_H smaller or larger than 5·75 show greater inhibitive power.

I (*b*) *Changes in Inhibitive Power and Gold Number of Gelatine Hydrolysed to Different Extents.*

The hydrolysis of gelatine was carried out by boiling a 3% solution in a silica flask in a paraffin bath whose temperature was maintained at 115°C. Any loss in weight due to heating, which was always small, was made good by adding distilled water. The inhibitive power was determined by finding out the amount of Ag_2CrO_4 that can be kept in solution state (i.e., till the red coloured precipitate appears) for 10 minutes, the volume of the mixture being kept constant throughout. The gold numbers were determined in the usual manner. The results of these experiments are given in Table IX.

TABLE IX.

Total volume of mixture (for inhibitive power) = 20 c. c.
Conc. of gelatine = 3%.
Conc. of gelatine (for protective power) = 0·001%.
Time of inhibition = 10 minutes.

Gelatine hydrolysed for hours.	Resulting p_H.	c. c. of $\frac{N}{100}$ Ag_2CrO_4.	Gold Numbers
0 (dispersed at 40°C.)	5·52	5·67	·0125
1	5·54	5·60	·0139
2	5·57	5·55	·0149
4	5·62	5·50	·0160
7	5·69	5·40	·0168
10	5·72	5·35	·0172

It will appear from the table that on hydrolysing the gelatine its p_H increases. This is in agreement with what has been observed by Bolam and Desai (loc. cit.) and by Desai and Nabar (Trans. Faraday Soc., loc. cit.). Also hydrolysed gelatine is found to be less effective in preventing precipitation than unhydrolysed gelatine. Bolam and Desai (loc. cit.) got a clear indication of a maximum in the value of time of inhibition (inhibitive power) at a certain stage of hydrolysis. Such a maximum in the inhibitive power has not been observed in the present case, probably due to the fact that hydrolysis has been carried out at a higher temperature.

The gold numbers increase on hydrolysing gelatine. If the gold numbers are taken to indicate the protective power of gelatine as is usually done, the results show that the protective power of gelatine decreases with an increase in the degree of hydrolysis. Ganguly (Journ. Indian Chem. Soc., 3,177, 1926) observed that on hydrolysing gelatine the gold numbers first decrease and then increase. In view of the fact that gelatine solution has been boiled freely in silica flask in Ganguly's as well as our experiments it is not understood why a minimum in the value of gold numbers has not been observed in the present case.

In order to see how far the changes in the inhibitive and protective power of gelatine on hydrolysis are brought about by a change in the acidity of gelatine, some experiments were also carried out by bringing back the p_H of hydrolysed gelatine to original value and then determine its inhibitive power and gold numbers. These results are given in Table X.

TABLE X.

Inhibitive and protective power on restoring p_H to original value.

Gelatine hydrolysed for hours.	p_H of hydrolysed gelatine brought back to the value.	c. c. of $\frac{N}{100}$ Ag_2CrO_4.	Gold Numbers.
1	5·52	5·66	·0126
2	5·51	5·67	·0128
4	5·50	5·66	·0128
7	5·52	5·67	·0128
10	5·50	5·67	·0130

It will appear from the above table that on restoring the p_H of hydrolysed gelatine to its original value (i. e., to the value of p_H of unhydrolysed gelatine) both the inhibitive power as well as gold numbers become the same as for unhydrolysed gelatine. These results thus show that changes in inhibitive and protective power brought about by hydrolysis are mainly due to a change in acidity of gelatine.

Bolam and Desai (loc. cit.) have stated that obviously inhibition and protection do not go hand in hand for there is a difference in the function of gelatine in the two cases. In the former rôle gelatine opposes the formation or growth of crystallisation centres and thus gives rise to a highly supersaturated solution; in the latter rôle gelatine prevents aggregation of small particles to larger masses and thus gives rise to a colloidal solution. On comparing the results of inhibition and gold numbers on hydrolysis it will appear that if gold numbers are taken to indicate the protective power, both inhibitive and protective power of gelatine decrease on hydrolysis. This is apparently not in agreement with the view of Bolam and Desai. Hydrolysis increases the degree of dispersion of the precipitate as has been observed by Bolam and Desai (loc. cit.) as well as in these experiments. This is due to the fact that there is less resistance to the growth of crystallisation centres in the former case (less inhibitive power) and therefore if the number of crystallisation centres is large, one would naturally expect that, other things remaining same, the particles of the precipitate will be smaller in hydrolysed than in unhydrolysed gelatine. The changes in the gold numbers on hydrolysis can be due to either changes in the protective power as seen from finer precipitate or changes in the acidity of gelatine which affect coagulation of gold sol. The original gold number having been obtained on restoring the original p_H, it appears that the gold number changes on hydrolysis are mostly due to the effect of changes of acidity on the coagulation of gold sol.

In Table XI are given the values of gold numbers for samples of unhydrolysed gelatine of different p_H.

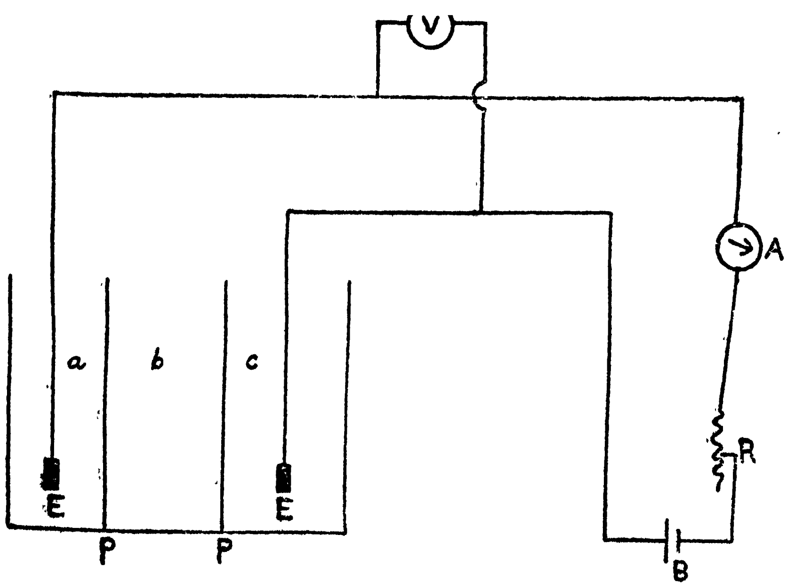
TABLE XI.

p_H of gelatine made equal to that of hydrolysed gelatine.	Gold Numbers.
5·57	·0139
5·62	·0160
5·69	·0165
5·72	·0172

It will appear from the results that with a decrease in the acidity of gelatine the gold number increases. Also whether the changes in p_H are brought about by hydrolysis (Table IX) or by adding sodium acetate (Table XI) the gold numbers change in the same fashion and almost to the same extent for same changes in p_H.

The changes in the inhibitive power of gelatine on hydrolysis would also seem to be wholly due to changes in its acidity as shown by results given in Tables VIII, IX and X. These results thus show that changes in the inhibitive power and gold numbers on hydrolysis are due to changes in its p_H.

DIA. A.



I (c) *Changes in the inhibitive power and gold number of gelatine electrodialysed to different extents.*

The arrangement for electrodialysis is shown in Diagram A. The gelatine solution was kept in the middle compartment of the electrodialyser ; the two side compartments were filled to the same level as the middle compartment with conductivity water. A direct current was passed using platinum plates as electrodes. Some soluble substances came out in the dialysate. Both inhibitive and protective power of gelatine electrodialysed for different periods as well as when the p_H was restored to original value were determined as before. The results are given in Tables XII and XIII.

TABLE XII.

Gelatine electro-dialysed for hours.	Resulting p_H.	c. c. of $\frac{N}{100}$ Ag_2CrO_4.	Gold Numbers.
0	5·52	5·67	·0125
1	5·48	5·75	·0119
2	5·42	5·88	·0108
4	5·35	6·05	·0098
7	5·28	6·18	·0090
10	5·20	6·30	·0084

TABLE XIII.

Inhibitive and protective power on restoring p_H to original value.

Gelatine electro-dialysed for hours.	p_H brought back to the value.	c. c. of $\frac{N}{100}$ Ag_2CrO_4.	Gold Numbers.
1	5·52	5·68	·0121
2	5·52	5·66	·0123
4	5·52	5·67	·0120
7	5·51	5·65	·0121
10	5·52	5·65	·0121

The results (Table XII) show that on electrodialysing gelatine solution both its acidity and inhibitive power increase. Presumably in the present case electrodialysis increases opposition to the growth of crystallisation centres and with it the supersaturation. The gold numbers decrease when gelatine solution is subjected to electrodialysis. The results in Table XIII show that by restoring the p_H to its original value both the inhibitive power and gold numbers are also brought back

to their original values as in the case of hydrolysed gelatine. Thus in this case also the changes in the inhibitive power and gold numbers on electrodialysing gelatine solution seem to be mainly brought about by changes in the p_H of gelatine.

It should be noted that on hydrolysing gelatine the gold number increases but on electrodialysing it the gold number decreases. In the former case the amount of 0·001% gelatine solution necessary for protecting 10 c. c. of Zisgmondy gold sol when 1 c. c. of 10% solution of NaCl is added increases while in the latter case it decreases. It will thus appear that hydrolysed gelatine prevents the coagulation of gold sol much less effectively than the electrodialysed gelatine. The present results distinctly show that the nature of products of hydrolysis and electrodialysis is very different and that the products of electrodialysis have greater protective power than products of hydrolysis.

In Table XIV are given the results of gold number determinations of gelatine solution which has not been electrodialysed but whose p_H has been reduced to the same value as obtained during electrodialysis by adding to the gelatine solution suitable amounts of acetic acid. The results show that whether changes in p_H are brought about by electrodialysing gelatine solution (Table XII) or by adding acetic acid to it (Table XIV) the gold number changes in the same manner and almost to the same extent for same changes in p_H.

TABLE XIV.

p_H of gelatine made equal to that of electrodialysed gelatine.	Gold Numbers.
5·23	·0088
5·28	·0093
5·35	·0099
5·42	·0108
5·48	·0120

The results given in Tables XI and XIV show that on adding either sodium acetate or acetic acid to gelatine solution the gold number increases. This is due to the fact that the added electrolytes try to coagulate the gold sol and therefore more of gelatine solution is required for protection. Also there does not appear any influence of the similarly charged ion in either case.

II. *Precipitation of AgI in samples of Gelatine of different p_H.*

These experiments were performed in the same manner as done with Ag_2CrO_4. The influence of light was minimised by working in sub-

dued light. On mixing solutions of $AgNO_3$ in gelatine, and KI in gelatine, the mixture attained somewhat greenish colour although no precipitation was visible. When precipitate of AgI began to separate from the mixture the colour changed to whitish yellow. The time required to get the whitish yellow colour of the same intensity as the standard was taken as a measure of inhibitive power in each case. The results of these experiments are given in Table XV.

TABLE XV.

Total volume of mixture = 20 c. c.
Concentration of gelatine = 3%.

3 c. c. of $\frac{N}{10}$ KI + 3 c. c. of $\frac{N}{10}$ $AgNO_3$

Column (1) c. c. of gelatine and column (2) Time of inhibition in minutes.

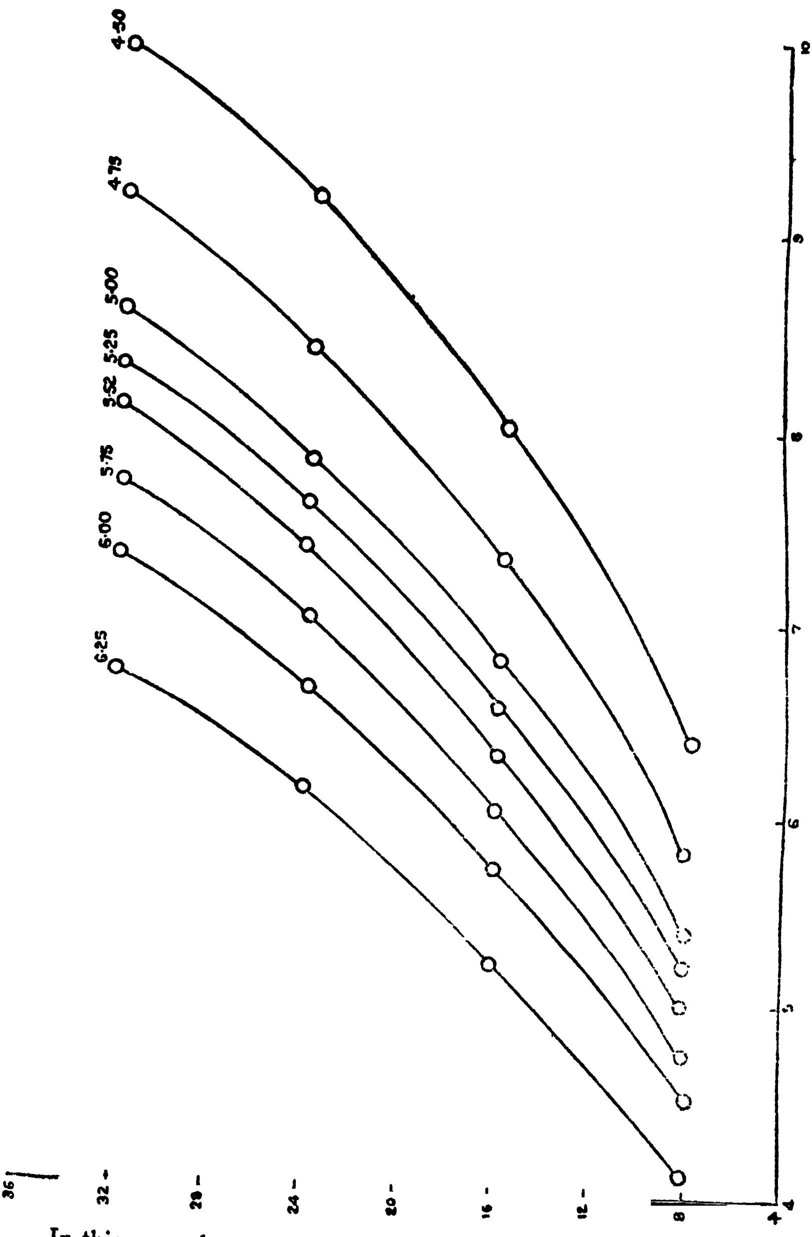
p_H=4·5		p_H=4·75		p_H=5·00		p_H=5·25	
(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
6·4	8	5·8	8	5·4	8	5·2	8
8·0	16	7·3	16	6·8	16	6·6	16
9·2	24	8·4	24	7·8	24	7·6	24
10·0	32	9·2	32	8·6	32	8·3	32

p_H=5·52		p_H=5·75		p_H=6·00		p_H=6·25	
(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
5·0	8	4·7	8	4·5	8	4·1	8
6·3	16	6·0	16	5·7	16	5·2	16
7·4	24	7·0	24	6·6	24	6·1	24
8·1	32	7·7	32	7·3	32	6·7	32

It will be seen from the above table that for all samples of gelatine the inhibitive power increases with an increase in amount of gelatine. This has also been observed in the case of Ag_2CrO_4. In Fig. 4 is given the plot of the amount of gelatine added (C) and the time of inhibition (T) for different samples of gelatine. It will appear from the figure that as the p_H of gelatine decreases the curves are displaced more and more away from the ordinate. In other words the inhibitive power decreases with a decrease of p_H of gelatine solution. This behaviour is therefore quite different from that with Ag_2CrO_4. This difference in the inhibitive power in the two cases probably influences the nature of rings of AgI

and Ag_2CrO_4 in gelatine. We have observed that the nature of AgI and Ag_2CrO_4 rings in gelatine is not similar. This point will be dealt with separately elsewhere.

FIG. 4



In this case also as with Ag_2CrO_4 the plot of log C and log T is a

straight line. The inhibitive power thus varies exponentially with the amount of gelatine.

III. *Precipitation of PbI_2 in samples of Gelatine of different p_H.*

When Pb $(NO_3)_2$ in gelatine and KI in gelatine are mixed, the mixture is clear and colourless. However on allowing the mixture to stand the colour becomes greenish in the beginning and yellow later on. The greenish coloured mixture did not contain any particles of PbI_2 and was clear, while the yellow coloured mixture was opaque. The time required to get both greenish and yellow colour of the same intensity as the standards was taken as a measure of inhibitive power in each case. The results are given in Table XVI.

TABLE XVI.

Total volume of mixture = 20 c. c.
Concentration of gelatine = 3%.

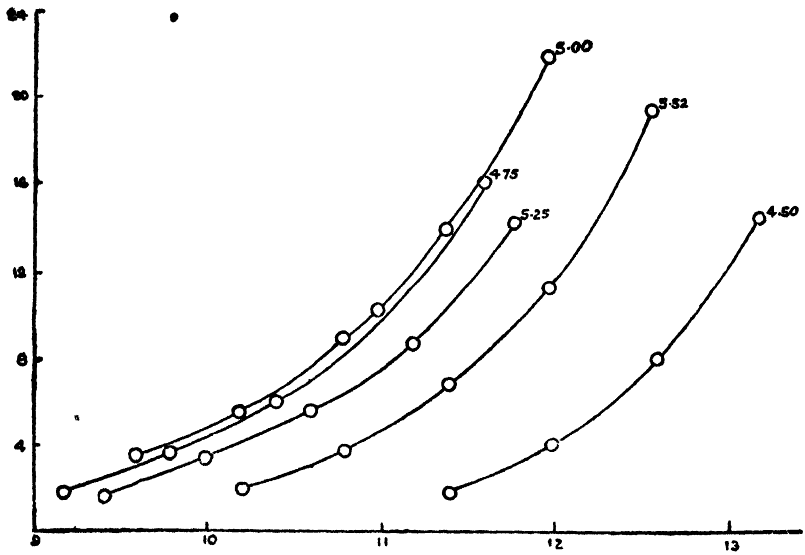
$$2{\cdot}5 \text{ c. c. of } \frac{N}{10} \text{ KI} + 2{\cdot}5 \text{ c. c. of } \frac{N}{10} \text{ Pb } (NO_3)_2.$$

Column (1) c. c. of gelatine and columns (2) and (3) Time of inhibition in minutes for appearance of greenish and yellow colour respectively.

p_H=5·52			p_H=5·25			p_H=5·00			p_H=4·75			p_H=4·5		
(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
10·2	2	3	9·4	2	3	9·6	3	6	8·6	-	2	11·4	2	3
10·8	3	7	10·0	3	6	10·2	5	10	9·2	2	4	12·0	3	7
11·4	7	11	10·6	5	9	10·8	9	15	9·8	3	7	12·6	7	13
12·0	11	19	11·2	8	15	11·4	13	25	10·4	6	12	13·2	14	25
12·6	19	35	11·8	14	24	12·0	21	37	11·0	10	20			
									11·6	16	33			

It will appear from the table that, as in the case of Ag_2CrO_4 and AgI, here also the inhibitive power increases with an increase in the amount of gelatine added. In Fig. 5 is plotted the amount of gelatine (C) against the time of inhibition (T) in different cases. It will be seen from the figure that the curves for p_H greater or smaller than 5·0 are displaced towards the right of the curve for p_H 5·0. In other words the inhibitive power of gelatine with reference to PbI_2 is maximum for p_H 5·0 and smaller for higher or lower values of p_H. This behaviour of inhibitive power might have an important bearing on the nature of PbI_2 rings in gelatine. The PbI_2 rings in samples of gelatine of different p_H are under investigation.

FIG. 5.



SUMMARY.

Inhibitive power of samples of gelatine of different p_H with reference to precipitation of Ag_2CrO_4, AgI and PbI_2 has been determined. In all the cases the inhibitive power increases with an increase in the amount of gelatine added and the plot of log C (amount of gelatine added) and log T (time of inhibition) is a straight line. It is found that the inhibitive power with reference to Ag_2CrO_4 is minimum for gelatine of p_H 5·75 and is greater for higher or lower values of p_H. In the case of AgI the inhibitive power continuously decreases with a decrease of p_H of gelatine. The inhibitive power with reference to PbI_2 is maximum for gelatine of p_H 5·0 and is smaller for higher or lower values of p_H. It is suggested that the difference in the inhibitive power with reference to Ag_2CrO_4, AgI and PbI_2 might have an important bearing on the nature of rings of these substances in gelatine.

On hydrolysing gelatine, its p_H and gold number increase while inhibitive power with reference to Ag_2CrO_4 decreases. When gelatine solution is electrodialysed, its p_H and gold number decrease while inhibitive power with reference to Ag_2CrO_4 increases. On bringing back the p_H of gelatine to its original value both the original inhibitive power and gold numbers are restored, thus showing that the changes are mainly due to changes in p_H of gelatine. It is observed that the products of hydrolysis have less protective power than products of electrodialysis.

The authors wish to thank Mr. G. M. Nabar for some help in the preliminary stages of this investigation and Prof. A. R. Normand for his interest in the work.

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Note:—Since the present paper was submitted for publication there has appeared a paper by Bolam and Donaldson (Trans. Faraday Soc., 29, 864, 1933) on the influence of gelatine on precipitation of silver chromate. From Fig. 1 of their paper it is clear that the inhibitive power (property of preventing the precipitation of insoluble salt) of gelatine steadily increases with an increase of acidity of gelatine (p_H range tried by them is 5·7 to 4·3). Our results (Fig. 2 of our paper) also point to the same conclusion for the same range of p_H and their results thus completely support our results. On p. 876 of their paper Bolam and Donaldson have calculated the degree of supersaturation according to the theory of Von Weimarn (Kolloid—Z., 2, 199, 1908, etc.; 3, 3, 1908, etc.; 4, 27, 1909 ; Grundzuge der Dispersoidchemie, 1911 ; Zum Lehre von dem Zustanden der Materie, 1914) and found that the degree of supersaturation increases slightly as the p_H decreases from 5·7 to 5·0, and then falls off more rapidly as the p_H is further decreased. They conclude that the degree of supersaturation, and therefore the inhibitive action of the gelatine, probably has an optimum value at P_H=5·0. It is difficult to reconcile this latter conclusion with the inferences that can be drawn from Fig. 1 of their paper as well as with our present results. It may however be pointed out that the optimum value of supersaturation for gelatine of p_H=5·0 seems to influence considerably the nature and number of Ag_2CrO_4 rings in gelatine, for as our results have shown (will be published in due course) best rings are obtained in samples of gelatine of p_H range 5·0 to 5·25.

THE ACTION OF NITRIC ACID ON TIN

By

G. S. KASBEKAR and A. R. NORMAND

Introduction.

The reaction between nitric acid and metals has been studied by many workers, but as it is very complex no general conclusion has yet been reached. At the end of this reaction there are generally present not only the nitrate and nitrite, but also a large number of reduction products of the acid. Ackworth and Armstrong (Jour. Chem. Soc. 32, 54, 1877) suggested that the nitrate was formed first, along with nascent hydrogen, which would reduce the excess nitric acid. Divers attempted to explain the formation of ammonia during the reduction (Jour. Chem. Soc. 43, 465, 1883) and Veley (Proc. Roy. Soc. 46, 216, 1890) attributed the inception of the reaction to the presence of nitrous acid. Gmelin (Hand-book of Chem. London, 359, 397, 1849) supposed that the metals are first oxidised, the oxide then dissolving in the acid to yield the nitrate. If the metal decomposes water there would also be products such as ammonia, hydroxylamine, etc. Bancroft (Jour. Phys. Chem. 28, 475, 1924) considers the reaction as a case of electrolytic corrosion, and points out that the hypothesis of Ackworth and Armstrong is a special case of this. On the same basis Milligan (Jour. Phys. Chem. 28, 744, 1924) and Joss (Jour. Phys. Chem. 1222, 30, 1926) have presented a systematic scheme representing the stages in which the reduction of nitric acid proceeds, but this scheme has not yet been proved to be applicable when the reduction is due to metals.

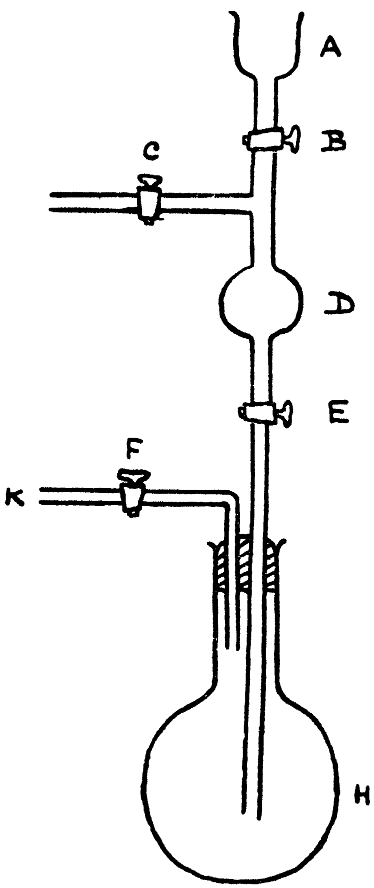
The literature shows that no worker has made a complete study of the reaction between a metal and nitric acid. In the case of tin Ackworth and Armstrong studied the gaseous products, whereas Walker and Veley (Jour. Chem. Soc. Trans. 846, 1893) studied the conditions in which tin goes into solution. It appeared to us that a systematic analysis of all the products formed in the mixture during the reaction between a metal and nitric acid, under varying conditions, would lead to definite conclusions about their stability and their causes of formation. Tin was chosen for a complete study on account of its amphoteric nature, its multivalent behaviour, and the instability of its compounds.

Experimental.

For the study of the products in solution, the following procedure was adopted. A known amount of the acid, of a definite concentration,

was introduced into a graduated 250 c. c. flask, kept in a water thermostat. The air was displaced by bubbling carbon dioxide through the acid for a long time. Small pieces of tin foil were introduced, and the time was measured for it to dissolve completely. Then the contents of the flask were diluted to 250 c. c. and the mixture was analysed qualitatively and quantitatively. The stannous tin was estimated by the iodine method of Lenssen as modified by Hallet (Jour. Soc. Chem. Indus. 35, 1087, 1916). The stannic tin was determined as the difference between the stannous and total tin. The total tin was estimated by weighing it as stannic oxide. Kjeldahl's method was used for the estimation of ammonia, with due precautions on account of the presence of other substances. Hydroxylamine was estimated by converting it to ammonia by the use of titanium chloride. The nitrates were estimated by the oxidation of ferrous chloride. All the above methods were tested beforehand and were found to be sufficiently accurate for the purposes of this investigation.

FIG. 1.



For the study of the gaseous products the apparatus shown in Fig. 1 was used. The tin was first introduced into the flask H and the stopper closed. With E closed, and B and C open, nitric acid was introduced through A into D. B was then closed, and the space above the acid in D was evacuated through C. The flask H was then evacuated through F. By opening E, acid could then be introduced into H, and the evolved gases collected through F. A Sprengel pump was used to evacuate the system and collect the gases.

For the estimation of the gaseous products, Milligan's method (Jour. Phys. Chem. 28, 544, 1924) was followed in detail. Nitrogen peroxide was estimated by absorption in concentrated sulphuric acid, and nitric oxide by absorption in a mixture of concentrated sulphuric acid and nitric acid in the proportion 50 : 1 by volume. The remaining

TABLE I.

Reaction between nitric acid and tin. (Varying concentration of nitric acid).

Experiment No.	HNO_3 conc. g/c.c.	Acid c.c.	Tin grams.	Temperature °C.	Time minutes.	Sn gms.	Sn gms.	NH_2OH gms.	NH_3 gms.	NO'_3 gms.	Gas at N.T.P. c.c.	NO gms.	N_2O gms.	N_2 gms.
1a	0·05	50	0·7	30	83	0·6920	0·000	0·00912	0·0246	...	...	...	...	...
1	0·10	50	0·7	30	15	0·6695	0·031	0·01873	0·01788	4·824	5·00	...	...	...
2	0·11	50	0·7	30	13	0·6664	0·033	0·02011	0·01685	5·304	5·45	...	...	...
3	0·12	50	0·7	30	11	0·6462	0·053	0·02311	0·01459	5·637	6·75	...	...	...
4	0·13	50	0·7	30	9	0·6337	0·066	0·02816	0·01390	6·096	10·10	...	...	...
5	0·14	50	0·7	30	7	0·6258	0·073	0·03268	0·01372	6·607	14·70	0·00104	0·00946	0·001434
6	0·16	50	0·7	30	6	0·5808	0·1185	0·02561	0·01456	7·523	18·10	0·00124	0·01030	0·002610
7	0·18	50	0·7	30	6	0·5698	0·1285	0·01890	0·01512	8·480	...	...	...	...
8	0·20	50	0·7	30	5	0·5546	0·1440	0·01650	0·01518	9·614	28·25	0·00277	0·01581	0·003779
9	0·25	50	0·7	30	4	0·5220	0·1770	0·01550	0·01475	11·228	31·30	0·00292	0·02155	0·004501
10	0·30	50	0·7	30	4	0·4926	0·2056	0·01420	0·01363	13·850	34·80	0·00274	0·02435	0·004968
11	1·40	50	0·7	30	1·5	0·00	0·6930	0·0000	0·000	...	Large volume of gas. Excess of NO.			

TABLE II.

Reaction between nitric acid and tin. (Varying temperature of reaction).

Experiment No.	HNO_3 Conc. g/c.c.	Acid c.c.	Tin grms.	Temperature °C.	Time Minutes.	Sn gms.	Sn gms.	NH_2OH gms.	NH_3 gms.	NO'_3 gms.	Gas at N.T.P. C.C.
1	0·14	50	0·7	0·0	35	0·6930	0·000	0·00916	0·02214	6·730	...
2	0·14	50	0·7	10	25	0·6893	0·010	0·01318	0·01694	6·716	...
3	0·14	50	0·7	15	18	0·6847	0·015	0·01919	0·01522	6·730	3·10
4	0·14	50	0·7	20	15	0·6699	0·029	0·02511	0·01418	6·699	3·10
5	0·14	50	0·7	30	7	0·6258	0·073	0·03268	0·01372	6·607	14·70
6	0·14	50	0·7	32	7	0·6219	0·075	0·03125	0·01413	6·653	16·30
7	0·14	50	0·7	34	7	0·6130	0·085	0·03011	0·01418	6·655	16·40
8	0·14	50	0·7	36	6	0·6073	0·091	0·02901	0·01453	6·708	...
9	0·14	50	0·7	40	6	0·5866	0·1111	0·02710	0·01453	6·708	16·60
10	0·14	50	0·7	70	3·5	0·00854	0·690	0·02113	0·00692	6·699	Large Volume
11	0·14	50	0·7	100	1·5	0·0011	0·695	0·01007	0·00173	6·658	

TABLE III.

Reaction between nitric acid and tin. (Varying amount of tin).

Experiment No.	HNO_3 Conc. g/c.c.	Acid c.c.	Tin grams.	Temperature °C.	Time Minutes.	Sn. gms.	Sn. gms.	NH_2OH gms.	NH_3 gms.	NO'_3 gms.	Gas at N.T.P.	NO gms.	N_2O gms.	N_2 gms.
1	0·14	50	0·35	30	4	0·3112	0·0361	0·01315	0·00813	6·651	8·5	...	...	...
2	0·14	50	0·70	30	7	0·6258	0·0730	0·03268	0·01372	6·607	14·7	0·00105	0.00946	0·001434
3	0·14	50	1·40	30	15	1·1850	0·2160	0·06029	0·02808	6·680	25·75	0·00187	0·02149	0·002538
4	0·14	50	2·10	30	25	1·807	0·301	0·09450	0·04101	6·135	36·10	0·00294	0·02930	0·003031
5	0·14	50	2·80	30	45	1·841	0·941	0·14390	0·06634	6·074	...	...	...	...
6	0·14	50	3·50	30	60	2·245	1·235	0·1767	0·08545	5·855	...	...	...	...

mixture, containing nitrous oxide and nitrogen was exploded with hydrogen, and the contraction in volume gave a measure of the amount of nitrous oxide present.

Discussion.

Dhar holds that nitric acid oxidises metals in exactly the same way as it oxidises substances such as sugar, starch etc. (Jour. Phys. Chem. 29, 142, 1925). Clearly the hydrogen theory of Ackworth and Armstrong cannot be applied to these latter substances. The undoubted similarities between the two cases are not sufficient to justify Dhar's general statement, as is shown by the various behaviours of different metals towards nitric acid. Dhar agrees with the view of Divers (Jour. Chem. Soc. 43, 465, 1883) that metals fall into two groups with respect to their reaction with nitric acid; the first group (copper, mercury, silver, etc.) do not give rise to hydrogen at any stage of the reaction but take up oxygen from the acid. The second group (iron, tin, zinc etc.) not only take up oxygen, but may even add hydrogen to the acid. There can be no real similarity between this latter behaviour and that of starch etc. Thus Dhar's theory cannot apply to the second group of metals, so that for these we must hold to the hydrogen theory. The argument that the hydrogen has insufficient time to carry out the reduction does not apply, because it is in the nascent state and therefore of great activity. Furthermore, the oxidation theory does not account satisfactorily for the formation of hydroxylamine, ammonia etc., at least in this reaction (as tin has no action on water at ordinary temperatures), and so it seems reasonable to suppose that the hydrogen produced is responsible for the reduction of the excess acid.

If the reduction of nitric acid be attributed to nascent hydrogen, the following equations would represent the process of formation of the various products:

$$2HNO_3 + 2H_2 = 2HNO_2 + 2H_2O$$
$$2HNO_3 + 3H_2 = 2NO + 4H_2O$$
$$2HNO_3 + 4H_2 = N_2O + 5H_2O$$
$$2HNO_3 + 5H_2 = N_2 + 6H_2O$$
$$2HNO_3 + 6H_2 = 2NH_2OH + 4H_2O$$
$$2HNO_3 + 7H_2 = N_2H_4 + 6H_2O$$
$$2HNO_3 + 8H_2 = 2NH_3 + 6H_2O$$

The formation of these products should not be supposed to take place directly, however, for there will be a series of intermediate stages which are not shown.

In the present experiments, the hydrogen necessary for the formation of the reduction products was calculated from the above equations, and was compared with the total quantity of hydrogen which tin is capable of producing when it dissolves in nitric acid. These two

TABLE IV.

Hydrogen necessary for the reduction products (Table I-III) compared with the hydrogen available from tin.

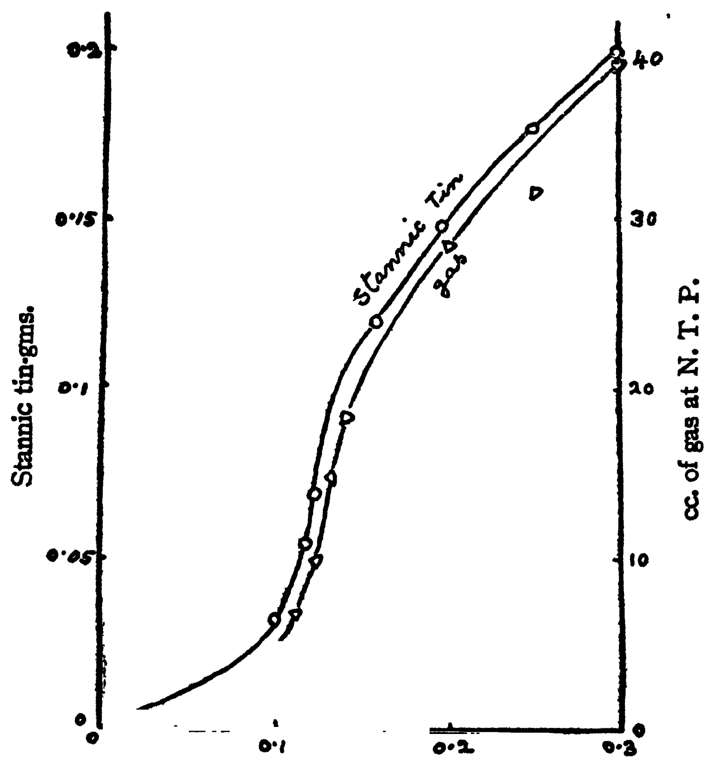
Table No.	Expt. No.	H_2 for NH_2OH gms.	H_2 for NH_3 gms.	H_2 for NO gms.	H_2 for N_2O gms.	H_2 for N_2 gms.	H_2 from Stannous tin gms.	H_2 from Stannic tin gms.	Total H_2 for the products gms.	Total H_2 from tin taken gms.
I	8	0·002998	0·007188	0·0002773	0·002898	0·001268	0·009419	0·004891	0·01482	0·014310
I	9	0·002616	0·006485	0·0002644	0·003947	0·001619	0·008865	0·006912	0·01493	0·014880
I	10	0·002580	0·006381	0·0002768	0·004460	0·001788	0·008366	0·006984	0·011548	0·011535
II	*2	0·002414	0·008007	...	...	...	0·01170	0·00034	0·01042	0·01204
II	*3	0·003519	0·007209	...	...	...	0·01162	0·00051	0·01073	0·01213
II	*4	0·004601	0·006716	...	...	...	0·01138	0·000985	0·01131	0·01236
III	2	0·005936	0·006497	0·0001052	0·001733	0·0005158	0·010630	0·002485	0·014750	0·013120
III	3	0·013270	0·011040	0·0001888	0·003936	0·0009163	0·020130	0·007336	0·029350	0·027466
III	4	0·01730	0·019420	0·0002963	0·005367	0·0010940	0·03068	0·010220	0·043477	0·04090

* In these experiments the gaseous products of the reaction were not analysed.

calculated values were found to be in excellent agreement (Table IV). This suggests that all the hydrogen necessary for the reduction of the excess nitric acid probably arises from the solution of the tin. Therefore, although the oxidation theory is not conclusively disproved, it is reasonable to conclude from the above that the view of Ackworth and Armstrong is correct as far as this reaction is concerned.

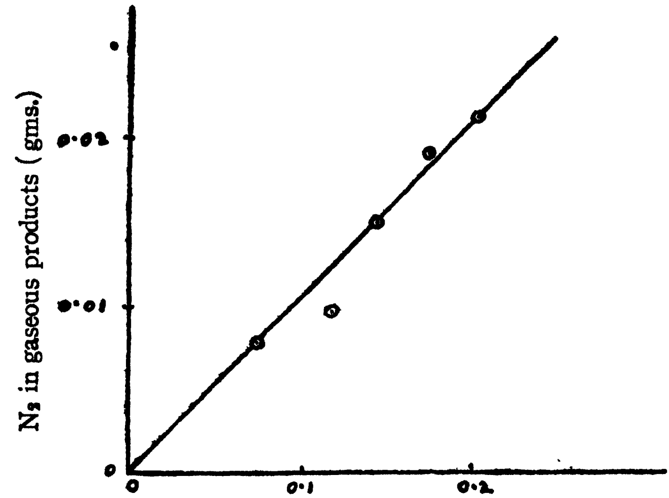
It is also interesting to observe that with increase of concentration of the acid, or of the temperature, the amounts of stannic salt, and the gaseous products, increase, and the amount of the reduction products in solution (hydroxylamine etc.,) decreases.

When the amount of stannic tin, and the volume of the gaseous products, are each plotted against the concentration of the acid (Graph I), the curves are found to be practically parallel. Also when the amount of stannic tin is plotted against the nitrogen content of the gaseous mixture, straight lines are obtained (Graphs II and III). It is clear then that there is a close relationship between the formation of stannic tin and that of the gaseous products.



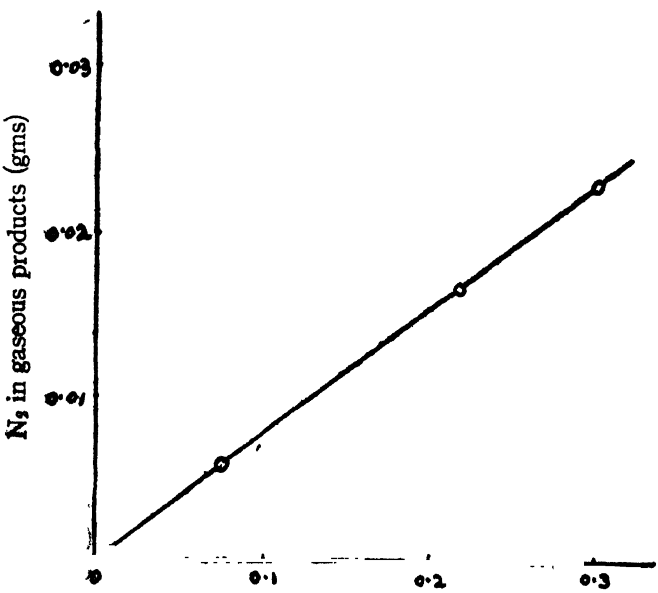
I

concentration of HNO_3 gm. c. c.



gms. of Sn tin

II



gms. of stannic tin.

III

At high temperatures or concentrations only stannic tin is formed, and there is a proportionate evolution of gas. At low temperatures or concentrations very little stannic tin is formed, and accordingly the gaseous products are negligible in amount.

Thermochemical data show that the formation of the stannous ion from tin involves an evolution of about two-thirds the heat evolved by the formation of the stannic ion. Nitrogen-hydrogen compounds are exothermic, whereas nitrogen-oxygen compounds are endothermic. It may therefore be assumed that the formation of nitrogen-oxygen compounds are associated with the formation of stannic ion, and that of nitrogen-hydrogen compounds with that of stannous ion.

It may be assumed that the nascent hydrogen produced by the action of tin on nitric acid is of two different activities, an assumption which is suggested by the results of others on the activity of nascent hydrogen (Comp. Treatise on Inorganic Chem. Mellor. Vol. I, p. 332). One variety of nascent hydrogen could cause the formation of the nitrogen-hydrogen compounds, and the other that of the nitrogen-oxygen compounds. These two varieties may arise in accordance with the following equations:—

$$Sn + 2HNO_3 = Sn(NO_3)_2 + 2H \quad \ldots\ldots \quad \text{I}$$
$$Sn + 4HNO_3 = Sn(NO_3)_4 + 4H \quad \ldots\ldots \quad \text{II}$$

The hydrogen from the first of these reactions would cause the formation of the nitrogen-hydrogen compounds, and that from the second of the nitrogen-oxygen compounds, thus accounting for the proportionality between the amounts of stannous tin and the nitrogen-hydrogen compounds on the one hand and those of stannic tin and the nitrogen-oxygen compounds on the other.

A closer inspection of the results shows that in all the experiments where hydroxylamine was formed, and the amount of gas evolved was negligible, an appreciable amount of tin was present in the stannic condition. If all the reduction products of nitric acid are arranged in their order of reduction, hydroxylamine is found to be between nitrogen and hydrazine. Since hydroxylamine is on the border line between the nitrogen-hydrogen and nitrogen-oxygen compounds, it seems probable that the combined action of both varieties of nascent hydrogen would account for its formation. On this view the formation of hydroxylamine may be represented as follows:

$$4Sn + 8HNO_3 = 4Sn(NO_3)_2 + 8H \ldots\ldots\ldots \text{(a)}$$
$$Sn + 4HNO_3 = Sn(NO_3)_4 + 4H \ldots\ldots\ldots \text{(b)}$$
$$2HNO_3 + (8H) + (4H) = 2NH_2OH + 4H_2O \ldots \text{(c)}$$

Therefore,

$$4Sn + Sn + 14HNO_2 = 4\,Sn(NO_3)_2 + Sn(NO_3)_4 + 2NH_2OH + 4H_2O \quad \ldots\ldots \quad 1$$

The formation of the other products, which are a result of the reduction of the acid by hydrogen of a single activity, may be represented as follows:—

TABLE V.

Stannous and stannic tin, calculated from the suggested equations and compared with the experimentally determined stannous and stannic tin.

Table No.	Experiment No.	Sn for NH_2OH gms.	Sn for NH_3 gms.	Sn for NH_2OH gms.	Sn for NO gms.	Sn for N_2O gms.	Sn for N_2 gms.	Sn Calculated gms.	Sn exptal. gms.	Sn Calculated gms.	Sn exptal. gms.
I	5	0·2324	0·3784	0·0581	0·003063	0·05046	0·01503	0·6108	0·6258	0·1266	0·073
I	6	0·1821	0·4017	0·04550	0·003647	0·05493	0·02734	0·5838	0·5808	0·1314	0·1185
I	8	0·1173	0·4187	0·02932	0·008137	0·08433	0·03959	0·5360	0·5540	0·1613	0·1440
I	9	0·1118	0·4069	0·02795	0·007700	0·1149	0·04715	0·5187	0·5220	0·1977	0·1770
I	10	0·1009	0·3760	0·02523	0·008058	0·1299	0·05205	0·4769	0·4926	0·2152	0·2056
III	2	0·2324	0·3784	0·0581	0·003063	0·05046	0·01503	0·6108	0·6258	0·1266	0·0730
III	3	0·4286	0·7747	0·1072	0·005498	0·1147	0·02659	1·2033	1·1850	0·2540	0·2160
III	4	0·6719	1·132	0·1679	0·008626	0·1584	0·03175	1·8039	1·807	0·3636	0·3010

$$3\,Sn + 16HNO_3 = 3Sn\,(NO_3)_4 + 4NO + 8H_2O \quad \ldots\ldots \quad II$$
$$2\,Sn + 10HNO_3 = 2Sn\,(NO_3)_4 + N_2O + 5H_2O \quad \ldots\ldots \quad III$$
$$5\,Sn + 24HNO_3 = 5Sn\,(NO_3)_4 + 2N_2 + 12H_2O \quad \ldots\ldots \quad IV$$
$$4\,Sn + 9HNO_3 = 4Sn\,(NO_3)_2 + NH_3 + 3H_2O \quad \ldots\ldots \quad V$$

To test these equations, they were used to calculate the amounts of tin which must dissolve to the stannous and the stannic condition to give the observed reduction products. These amounts were then compared with the experimental values. Table V shows that the agreement is good.

The above equations can thus be accepted as representing the processes of reduction of the excess nitric acid.

Further investigation is now in progress, with a view to determining the intermediate stages of the reaction.

Summary.

The reaction between tin and nitric acid under varying conditions has been studied by estimating all the products formed during the reaction, both in the dissolved and in the gaseous state. It has been shown that during the reaction in addition to the formation of stannous and stannic salts, hydroxylamine, ammonia, nitric oxide, nitrous oxide, and nitrogen are formed. Neither nitrous acid nor hydrazine were formed under the conditions studied.

It has been pointed out that the variations in the stannic tin and the gaseous reduction products of excess nitric acid go hand in hand; likewise the variation of stannous tin in solution and the variation of the reduction products in solution, namely hydroxylamine etc.

In an attempt to explain the reduction of excess nitric acid not only has it been shown that nascent hydrogen is the probable reducing agent, but it has further been suggested that the nascent hydrogen produced by the dissolution of tin in nitric acid may be of two different activities, the dissolution of tin to the stannous condition producing hydrogen of one activity, and the dissolution of tin to the stannic condition producing hydrogen of another activity.

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1st July, 1933.

A NOTE ON CATALYSIS IN THE PYROLYSIS OF HYDROCARBONS

By

T. S. WHEELER.

The increasing number of technical processes which involve the heat treatment of hydrocarbons, such as the liquid and vapour phase cracking of oils, and the pyrolysis and polymerisation of hydrocarbon gases, has necessitated the development of special heat and corrosion resisting alloys as reaction plant materials. The choice of a suitable material for any particular process requires an understanding of the catalytic rôle played by these alloys in the decomposition of hydrocarbons. This probably takes place with the elimination of hydrogen and the formation of fugitive unsaturated groups which either polymerise or further decompose.

In the application of these processes it is essential that the material of the reaction plant should be such as will inhibit the decomposition of the hydrocarbon to carbon and hydrogen only. A good "anti-catalyst" for the decomposition is required.

The following theory regarding the catalytic properties of metals and metallic alloys in the presence of hydrocarbons at high temperatures has been evolved by the author, and serves as a qualitative guide in the choice of plant materials for such reactions.

The basis of the theory is that catalytic activity in the heterogeneous reactions under consideration depends upon the presence of loosely bound electrons on the surface of the catalyst. These form centres of intense activity around which decomposition reactions vigorously occur. Conversely the absence of such energising centres inhibits chemical activity. To illustrate these remarks we may mention the activity of iron in promoting complete decomposition of hydrocarbons to carbon and hydrogen. This is to be referred to the presence of mobile electrons.

Now compounds such as silica with a stable electronic structure do not catalyse directly the decomposition of hydrocarbons to carbon and hydrogen. R. V. Wheeler and Wood (Fuel, *9*,567, 1930) have shown that alloy steels behave in this respect like silica. This leads to the idea that the high electrical resistance of these alloys is due to the fact that the electrons are not mobile. We note in this connection that the following properties are common in certain alloys:—(1) High

electrical resistance, (2) low thermal conductivity, (3) High melting point, (4) High tensile strength, (5) A high hardness number (6) High resistance to the action of chemicals, and that all may be referred to the stability of electron groups.

If therefore we correlate these properties with the anti-catalytic action we see that the electrical resistance of an alloy may serve as an index of the lack of mobility of the electrons, and hence of the anti-catalytic properties in the decomposition of hydrocarbons.

With regard to the metals which alloyed with iron give suitable alloys, it should be noted that all the elements of value as additions to iron in the production of alloy-steels lie at or near the minima of the curve of atomic volumes plotted against atomic number. It is logical therefore to expect that the elements of low atomic weight lying at the first and second minima, beryllium, boron and aluminium may prove of value in the production of alloy steels and also of anti-catalytic materials.

A SIMPLIFIED METHOD FOR THE PREPARATION OF ANILIDES

By

R. C. SHAH and R. K. DESHPANDE.

The preparation of an anilide from a carboxylic acid is a common operation in organic chemistry. It is usually carried out in two ways:—

(1) By heating the acid and the aniline together at a high temperature. This is a tedious process and takes a long time and the yields are not always satisfactory.

(2) Through the acid chloride, the acid being converted into the acid chloride by the action of phosphorus pentachloride. The acid chloride has to be separated from the other product of the reaction *viz.* phosphorus oxychloride, which is removed by distillation under reduced pressure, before it can be utilised for the preparation of the anilide. This is essential as phosphorus oxychloride, if present, would itself react readily with the aniline, giving compounds like $C_6H_5NH.POCl_2$, $CH_5NH.PO.=NPh$, and $(C_6H_5NH)_3.PO$. (Cf. Mich and Schultze, Ber., 26, 2939; Mich and Silberstein, ibid, 29, 720; Annalen, 326, 245; Mich and Soden, Annalen, 229, 339).

Thus a method is lacking whereby an acid can be readily converted into an anilide.

Barnett (Chem. News, 1926, p. 190) has described a method for the preparation of anilides wherein 1 mol. of the acid and 1 mol. of the amine are dissolved in 2 to 3 parts of pyridine, the mixture cooled in a freeezing mixture and thionyl chloride slowly added. After keeping for some time, the mixture is poured into water and the precipitated anilide filtered and purified. No quantitative mention is made of the yields obtained by this method, it being merely stated that very good results were obtained with some acids and that the method failed in some cases.

In connection with investigations on the chemistry of anilide-imido-chlorides which have been in progress in these laboratories for some time, the authors had occasion to prepare a large number of anilides. Several attempts were made to devise a simplified method for

the purpose, and ultimately the following simple and quick method for the preparation of anilides was worked out.

The method consists in the addition of dimethyl-aniline, diethyl-aniline or pyridine to the crude mixture of the acid chloride and phosphorus oxychloride, obtained by the action of phosphorus pentachloride on the acid, and subsequent addition of the amine to the well cooled mixture.

The method considerably simplifies the preparation of anilides, as it does away with the tedious process of the removal of phosphorus oxychloride and the isolation of the acid chloride. As will be seen from the experimental portion, high yields almost as good as those by the use of pure acid chlorides, can be obtained by this method.

The success of the method is doubtless due to the fact that the tertiary amine greatly promotes the reaction between the aniline and the acid chloride, which thus preferentially reacts, to the almost complete exclusion of phosphorus oxychloride from reaction.

The general applicability of the method has been established by testing it with a number of acids, mostly aromatic, and different types of primary and secondary aromatic amines.

An attempt to extend the method to the preparation of esters was unsuccessful, low yields being obtained.

The method is well adapted for the preparation of anilides, either in small quantities for characterising acids, or in quantity for other work.

EXPERIMENTAL.

General Method.—

The mixture of the acid chloride and the phosphorus oxychloride, obtained by the action of phosphorus pentachoride on the acid (1 mol.), is cooled, preferably in a freezing mixture, and dimethyl-aniline, diethyl-aniline, or pyridine (2 mols.) added in small portions. The amine (1·2-1·5 mols) is then added gradually, with stirring to the cooled mixture. With the progress of the reaction which is very rapid, the mixture usually thickens considerably, and sometimes solidifies towards the end. By treating the product successively with dilute hydrochloric acid, dilute sodium hydroxide and finally with water, the anilide is obtained fairly pure, and may be further purified by crystallisation if necessary.

TABLE I.

The following anilides were prepared by this method from different acids by the action of aniline.

Anilide.	Yield of the pure crystallised product. % of Theory.	M.P.	M.P. given in literature.
Benzanilide	90%	162°	163°
p-nitrobenzanilide	85%	216°	213°
m-nitrobenzanilide	80%	155°	154°
o-nitrobenzanilide	75%	154°	155°
o-chlorobenzanilide	80%	114°	114°
p-bromobenzanilide	80%	205°	197°
Anisanilide	80%	169°	168-169°
α-naphthanilide	85%	160°	160°
β-naphthanilide	85%	167°	170°
Cinnamanilide	70%	149°	150°
Trichloracetanilide	80%	94°	94°

TABLE II.

The following benzoyl compounds were prepared from various primary and secondary aromatic amines and benzoic acid.

Compound.	Yield of the pure crystallised product % of theory.	M.P.	M.P. given in literature.
benzoyl-o-nintraniline	75%	93°	94°
„ „ -m-nitraniline	80%	155°	155°
„ „ -p-nitraniline	80%	197-198°	199°
„ „ -o-toluidine	75%	142°	143°
„ „ -m-toluidine	80%	126°	125°
„ „ -p-toluidine	85%	157°	158°
„ „ -diphenylamine	75%	178-179°	180°
„ „ α-naphthylamine	80%	159°	160°
„ „ -β-naphthylamine	80%	162°	162°
„ „ -Phenylhydrazine	75%	168°	168°
„ „ -thiodiphenylamine	80%	163°	165°
dibenzoyl-o-phenylenediamine	70%	295-298°	301°

The authors are thankful to Dr. A. N. Meldrum for his kind interest in the work.

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DERIVATIVES OF SALICYLIC ACID—PART VII.

INTERACTION OF THIONYL-CHLORIDE WITH ESTERS OF AROMATIC HYDROXY ACIDS IN THE PRESENCE OF FINELY DIVIDED COPPER.

PART—II.

SYNTHESIS OF THIO-ETHER OF 4-METHOXY SALICYLIC ACID AND RELATED COMPOUNDS.

By

N. W. HIRWE **G. V. JADHAV** **Y. M. CHAKRADEO**

The methyl ester of 4-methoxy salicylic acid was found to be a suitable substance to continue the study of the interaction of thionyl chloride with esters of aromatic hydroxy acids in presence of finely divided copper; described in the Derivatives of Salicylic acid Part VI —Interaction of thionyl chloride with aromatic hydroxy acids in the presence of finely divided copper Part I: Synthesis and constitution of thio-ether of salicylic acid and related compounds. (Journal Americon Chemical Soc.) (insert ref. when published.)

Esters have been specially chosen in order to control the formation of anhydrides which occurs with O-hydroxy benzoic acids in presence of thionyl chloride.

With methyl salicylate it has been shown that the reaction is catalytic and continuous as long as the sulphur dioxide liberated in the reaction is made available. The following equations with 4-methoxy methyl salicylate give the different stages in the reaction:—

$$3Cu + 4\,SOCl_2 = 3\,CuCl_2 + S_2Cl_2 + 2SO_2$$

$$2C_6H_3\underset{2}{(OH)}\underset{4}{(OCH_3)}\underset{1}{COOCH_3} + S_2Cl_2 + Cu = [C_6H_2(OH)(OCH_3)COOCH_3]_2S + 2HCl + Cu + S$$

$$2CuCl_2 + SO_2 = Cu_2Cl_2 + SO_2Cl_2$$

$$Cu_2Cl_2 + 2SOCl_2 = 2CuCl_2 + SCl_2 + SO_2$$

$$2C_6H_3\underset{2}{(OH)}\underset{4}{(OCH_3)}\underset{1}{COOCH_3} + SCl_2 + Cu = [C_6H_2(OH)(OCH_3)COOCH_3]_2S + 2HCl + Cu$$

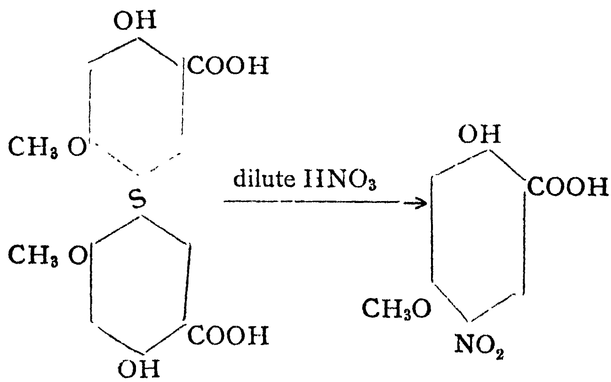
The above scheme represents the mechanism truly because (i) copious fumes of sulphur dioxide and hydrogen chloride are evolved; (ii) Free sulphur is found in the reaction mixture (iii) Sulphur mono-chloride and sulphur dichloride give the desired sulphides when used in the presence of finely divided copper; and (iv) The reaction which is

absent in the presence of anhydrous cupric chloride begins on passing SO_2 into the reaction mixture and a good yield is obtained. Addition of water to the reaction mixture containing anhydrous cupric chloride or use of hydrated cupric chloride affects the reaction favourably.

It is interesting to note that the additional hydroxy group in the 4-hydroxy methyl salicylate (methyl β resorcylate) adds to the vigour of the reaction, so that it becomes uncontrollable and no crystalline product can be isolated, while the reaction progressed smoothly on converting it to methoxy.

Formation of acetyl and benzoyl derivatives shows that the -OH group is free and the linking is nuclear. When the comp. (thio-ether) is heated hydrogen sulphide is evolved ; this supports the sulphide structure. The probability due to orienting influences in the molecule is that the sulphur links in-5 position. This is confirmed by nitration of comp. I with dilute nitric acid to give comp. II which is identical with the 4-methoxy 5-nitro salicylic acid described by Gilbody and Perkin (J. Chemical Soc. 1902, 81, 1056).

I.



II.

M.P. 226° M.P. 232°

EXPERIMENTAL.

Bis-3-carbomethoxy-4-hydroxy-6-methoxy phenyl thio-ether :—

The methyl ester of 4-methoxy salicylic acid (35g.) was mixed with thionyl chloride (50g.) and copper dust (20g.) was gradually added to it, when dense fumes of hydrogen chloride and sulphur dioxide were evolved. The reaction-mixture was protected from moisture by means of a cork carrying a glass-tube bent twice at right angles instead of the usual calcium chloride tube. The mixture was left at room-temperature overnight and then warmed on water-bath for some time The mixture was then extracted with hot chloroform and filtered from copper dust. On evaporation of the solvent a pasty solid was left be-

hind which was washed with petroleum ether and crystallised from dilute acetic acid in colourless needles. It is insoluble in water and petroleum ether and soluble in benzene, acetic acid, acetone, methyl and ethyl alcohols, and carbon disulphide. It gives bluish violet colouration with ferric chloride solution. (Found: S, 8·2 ; equivalent 196·8 ; $C_{18}H_{18}O_8S$ requires S 8·1 per cent. equivalent 197·0).

Bis-3-carboxy-4-hydroxy-6-methoxy-thio-ether :

The ester (10g.) was treated with 10 per cent. sodium hydroxide solution (100c.c.) and boiled with a reflux condenser for about two hours. The solution was then treated with dilute hydrochloric acid when a solid separated which was washed with water and crystallised from glacial acetic acid in colourless plates, m. p. 226^0. It is insoluble in water, dilute acetic acid and petroleum ether and soluble in acetone, ethyl and methyl alcohols and glacial acetic acid, and difficultly soluble in chloroform and benzene. It gives bluish violet coloration with ferric chloride solution. (Found: S, 8·4; equivalent 183.2; $C_{16}H_{14}O_8S$ requires S, 8·74 per cent. and equivalent 183·0.)

Sodium salt :

Sodium salt of bis-3-carboxy-4-hydroxy-6-methoxy thio-ether was prepared by neutralising the acid with sodium hydroxide solution. It was evaporated to dryness on a water-bath and recrystallised from dilute alcohol as it is easily soluble even in cold water. It crystallises in colourless needles. (Found : Na,10·6; H_2O 3·9 ; $C_{16}H_{12}O_8S\,Na_2,H_2O$ requires Na, 10.75 ; H_2O,4.2 per cent.)

Potassium Salt :

This was prepared by neutralising the acid with potassium hydroxide solution. It was then evaporated to dryness on a water-bath. It is fairly soluble in hot water from which it is recrystallised as colourless needless. (Found: K, 16. 1 ; H_2O, 7.4 ; $C_{16}H_{12}O_8SK_2$, $2H_2O$ requires K, 16·3 ; and H_2O, 7·5 per cent.)

Calcium Salt :

This was prepared by first neutralising the acid with ammonium hydroxide solution and then adding calcium chloride solution to it. The precipitate was filtered, washed and recrystallised from hot water as colourless needles. (Found : Ca, 8·2 ; H_2O, 14·9 ; $C_{16}H_{12}O_8SCa$, $4H_2O$ requires Ca,8·4 and H_2O, 15·1 per cent.)

Barium Salt :

This was prepared by treating the ammonium salt solution of the thio-ether with the solution of barium acetate when the barium salt was precipitated. It was washed, and recrystallised from hot water as colourless needles. (Found: Ba, 23·7 ; H_2O, 12.7 ; $C_{16}H_{12}O_8SBa$, $4H_2O$ requires Ba, 23.9 ; and H_2O, 12.6 per cent.)

4-methoxy-5-nitro salicylic acid :

Bis-3-carboxy-4-hydroxy-6-methoxy phenyl thio-ether (2g.) was treated with dilute nitric acid (20ccs. of Nitric acid (Sp- Gr. 1.45) and, 80 ccs. of water) and the mixture warmed till a colourless solution was obtained. The mixture was diluted with water and the solid obtained was washed and recrystallised from dilute alcohol in colourless needles. m. p. 232^0. (Found : N, 6.4; $C_8H_7O_6N$ requires N, 6.6 per cent.) Gilbody and Perkin (Jour. Chem. Soc. 1902, 81, 1056) give m. p. 230^0.

Bis-3-carbomethoxy-4-acetoxy-6-methoxy-phenyl thio-ether :

Bis-3-carbomethoxy-4-hydroxy-6-methoxy phenyl thio-ether (2g.) was gradually added to acetic anhydride (13g.) containing a few drops of concentrated sulphric acid. The mixture was gently warmed till a clear solution was obtained. It was then poured over crushed ice and the solid obtained was washed and recrystallised from alcohol in colorless needles m. p. 162^0. It is soluble in acetic acid, chloroform, acetone and ethyl and methyl alcohols; insoluble in water, benzene and petroleum ether. (Found : S, 6.4; $C_{22}H_{22}O_{10}S$ requires S,6.7. per cent.)

Bis-3-carbomethoxy-4-benzoyloxy-6-methoxy phenyl thio-ether :

Bis-3-carbomethoxy-4-hydroxy-6-methoxy phenyl thio-ether (1.5g.) was dissolved in pyridine and benzoyl chloride (5g.) was gradually added to it. The mixture was refluxed on a water-bath for about three hours. On pouring the solution over crushed ice a liquid separated which slowly solidified on repeated washing with ice-cold water. It was crystallised from alcohol in colourless needles, m. p. 185^0. (Found : S, 5.2 ; $C_{32}H_{26}O_{10}S$ requires S, 5.3 per cent.)

Bis-3-carbamido-4-hydroxy-6-methoxy-phenyl thio ether :

Bis-3-carbomethoxy-4-hydroxy-6-methoxy phenyl thio-ether (4g.) was put into liquor ammonia (100 ccs.) and the mixture was mechanically shaken for about eight hours, when a clear solution was obtained. The solution was evaporated on a water-bath and the solid was crystallised from boiling glacial acetic acid, in gritty flakes. m. p. 187^0 with decomposition. It is practically insoluble in most of the common organic solvents. (Found: N, 7. 4 ; S, 8.6 ; $C_{16}H_{16}O_6N_2S$ requires N, 7.7 and S, 8.8 per cent.)

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THE EFFECT OF TEMPERATURE IN FERROMAGNETIC CRYSTALS

by

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"Nous avons déduit des propriétés des lignes d'egale aimantation —(in the H-T plane)—l'impossibilité d'une équation d'etat ferromagnetisme, fondée sur la loi classique du paramagnetisme et sur celle du champ moleculaire, et nous avons reconnu la nécessite de retoucher les postulats fondamentaux."

—Weiβ et Forrer [*Ann. de Phys.* Jan-Fevrier 1926 Tome V, page 153]

"The results of experiments do not appear to be in agreement with the Weiβ theory of specific heats of Ferromagnetic substances."

—"Specific Heats of Ferromagnetic Substances" by Sucksmith and H. H. Potter, *Proc. Roy. Soc.* Vol. 112, 1926, p. 176.

[1°] *The scope of the present Paper and some introductory remarks :*

A brief summary of the writer's first paper* was published in the *Proc. Cambridge Phil. Soc.*, Vol. 23, pt. 2, and the main criticism of the work came from Debye and Pauli in an informal conference on Magnetism held at Zürich. It was to the effect that the concept of temperature was neglected and that the problem was treated as simply a geometrical, statical one.

The object of the present paper is to take account of Temperature effects, and to revise and consolidate in that light some of the main results obtained before. The exact bearing of the quotations at the top will become clear when we shall come to explain Weiβ's latest experiments (1926) on theoretical grounds.

It may be recalled here for the sake of definiteness, that in the previous paper, on the assumptions that

(i) elementary molecular magnets in a ferromagnetic crystal are nothing but atoms with magnetic properties due to the presence of electronic orbits,

* Published in *extenso* as "A Contribution to the Theory of Ferromagnetic Crystals." *Phil. Trans. Roy. Soc. London*, Series A, Vol. 228, pp. 63-114. (1929).

(ii) that in a "space-centred" structure,—whether cubic or non-cubic,—the atoms split themselves, in any steady state, into two groups with two distinct directions for their magnetic axes. The two groups severally belong to the two component simple lattices. The two directions coincide for saturation, and are exactly opposite for the unmagnetised state,

we found that,—

(iii) Webster's experimental results could be explained theoretically, without postulating the existence of any 'molecular field', but simply with the aid of the 'atomic actions'.

It was also shown that—

(iv) 'the atomic actions' could be effectively substituted for by a molecular field according to a general law, which included both the cubic and the non-cubic cases,—and which in the particular non-cubic case (of Pyrhotite) reduces to Weiβ's law of 'simple proportionality'.

Now, out of these four items, it is only (ii), the assumption of 'two groups', that is going to be replaced in this section. And as it was used only in the third section dealing with non-saturated states its revision does *not affect* our main results, as they referred to Saturation states.

The grounds for revision are mainly three :—

1. It is plausible in the case of a "space-centred" structure, where we have exactly two simple component lattices ; but what about 'simple', or 'face-centred' structures ? There is no definite way of dividing the atoms into two groups.

2. The second is now a theoretical objection to some extent : writing in 1925, L. W. Mckeehan says,

"It appears after a little study of the older theories that none of them have taken sufficient notice of the fact that the medium, the behaviour of which they attempt to describe is really discontinuous. Some of the theories are quite obviously faulty in this respect, introducing intrinsic fields of force to a greater or less extent, and thereby avoiding consideration of the physical basis of magnetic retentivity and hysteresis. Others begin with the atoms but introduce what amounts to the assumption of a continuous medium when groups of atoms are pictured as undergoing simultaneously equal changes in magnetization." —*Phys. Review* 1925, Vol. 26, page 275.

It will be observed that this criticism is as much directed against our assumption of 'two groups', as it is against Weiβ's molecular field. Mckeehan suggests in his paper that the magnetizing process in a body must proceed discontinuously in space as well as in time. Now, it is not impossible to reply to Mckeehan's criticism if the group-assumption were really found indispensible. But, as will be seen,

3. the way in which the concept of Temperature is to be introduced, renders it unnecessary to maintain,

Conversely, also, if the assumption is given up, temperature must come in to explain the existence of states other than that of Saturation.

[2°] *A historical Note:—*

In his article on "Para-and-diamagnetism" in [*Bull. Nat. Res. Council*, Vol. 3, part 3. p. 68 (1922)], Wills has summarised the various attempts to introduce temperature and derive the "equation of magnetic state" of a substance—*i.e.* to say to correlate in a relation temperature, applied field, and magnetization, viz.

$$f(\mathrm{H}, \mathrm{T}, \sigma) = 0.$$

A few points, however, need to be noted here, so as to make it clear wherein the contribution of this paper lies.

1. Langevin was the first in the field. He introduced temperature as in the usual Boltzman-Maxwell statistical way, and obtained the equation of magnetic state for a paramagnetic substance in the form

$$\sigma = \sigma_0 \left(\cosh a - \frac{1}{a}\right), \quad a = \frac{\mu \mathrm{H}}{\mathrm{RT}}.$$

2. This relation if written in the form

$$\text{Magnetization} = \sigma = \phi\left(\frac{\mathrm{H}}{\mathrm{T}}\right),$$

bears close resemblance to the equation of state of an ideal gas, viz. $pv = \mathrm{RT}$; or

$$\text{density} = f\left(\frac{p}{\mathrm{T}}\right).$$

Now, by taking account of internal pressure, Van der Waal obtained the equation of state which included liquids as well. By analogy, Weiβ introduced the concept of an internal (moleculaire) field, and obtained the equation of magnetic state for ferromagnetic substances as well, in the form

$$\sigma = \phi\left(\frac{\mathrm{H} + \mathrm{H}_m}{\mathrm{T}}\right).$$

[This result, as we shall come to consider more fully later, is contradicted by his latest experiments. 1926.]

3. Many of the experimental facts since Langevin's paper (1905), did not accord with the main results of his theory which were wo,—

$$\begin{cases} (i) & \dfrac{\partial \chi}{\partial \mathrm{T}} = 0, \text{ for diamagnetic substances} \\ (ii) & \chi \propto \dfrac{1}{\mathrm{T}}, \text{ for paramagnetic } \quad " \end{cases}$$

where χ = susceptibility.

This led to various attempts to modify his theory. The main workers in the field have been Honda and Okubo, Gans, Oxley and Frivold. All these attempts may be grouped as those independent of Quantum hypotheses.

But, discrepancies in other directions were revealed, which necessitated the modification of Langevin's theory:—

In 1911 Nernst showed that, in contradiction to the laws of classical mechanics, the specific heats of polyatomic gases appear to decrease with decrease in temperature, and the results were ascribed to the behaviour of that portion of the specific heat which depends upon the rotation of molecules. Meanwhile, the experimental investigations of Onnes, Oosterhuis, Perrier, du Bois, Honda and Owen on the variation (with temperature) of the susceptibility of paramagnetic substances, gave results which were in opposition to equipartition theories of paramagnetism. The theory of magnetism was thus in a dilemma similar to that in which the theory of specific heat found itself.

Accordingly modifications were introduced by bringing in Quantum hypotheses. And in this connection may be mentioned the names of Oosterhuis, Keesom, Gans (again), Weyssenhoff and Reiche.

It is important to observe, however, that none of these attempts seems to consider a crystal structure, such as we have under contemplation. The principal aim of the paper, therefore, will be to introduce temperature in a way consistent with the lattice-theory of crystal-structures.

[3°] *Temperature effects in magnetic crystals to be correlated with Libration frequencies of atoms:—*

The way to introduce temperature in the present theory is somewhat similar to that which Born adopts in his "Dynamik der Kristallgitter," in dealing with specific heats of solids. There, only the translational displacements of atoms are considered, and only the corresponding frequencies are taken into account. In the present case (of ferromagnetic crystals), since the atoms have associated with them a privileged direction,—viz. the axes of their magnetic moments, —it is necessary to introduce Librational frequencies. Thus in place of Born's—

"Die potentielle Energie zwischen einer Partikel der Basis und einer andern, beide in Gleichgewichtslagen, hat den Wert,

$$\varphi\left(\left|r_{kk'}^{ll'}\right|\right)$$

we have to write

$$\varphi\left(\left|r_{kk'}^{ll'}\right|, \left|\theta_{kk'}^{ll'}\right|, \left|\phi_{kk'}^{ll'}\right|\right).$$

The notation is the same as in Born's,—

$$\left. r^{ll'}_{kk'} = r^{l}_{k} - r^{l'}_{k'} \right\}, \text{ (vector-equation).}$$

r^{l}_{k} denotes the vector joining the origin to the 'k'th particle in 'l'th cell.

(θ, ϕ) denote the orientation of the axis of the magnetic moment of an atom. Of course

$$\left. \begin{aligned} \theta^{ll'}_{kk'} &= \theta^{l}_{k} - \theta^{l'}_{k'} \\ \phi^{ll'}_{kk'} &= \phi^{l}_{k} - \phi^{l'}_{k'} \end{aligned} \right\} \text{These are scalar equations.}$$

[It may be pointed out that so far as the purely magnetic potential energy is concerned, the $\varphi^{ll'}_{kk'}$—function is, (if the atoms be regarded as simple doublets),—

$$\frac{\mu^{l}_{k} \cdot \mu^{l'}_{k'}}{\left| r^{ll'}_{kk'} \right|^3} \left\{ \sin \theta^{l}_{k} \cdot \sin \theta^{l'}_{k'} \cos \phi^{ll'}_{kk'} - 2 \cos \theta^{l}_{k} \cdot \cos \theta^{l'}_{k'} \right\}.$$

Cf :—Jean's *Electricity and Magnetism* p. 379

Now, first of all, neglecting T, we determine the direction of magnetization (σ). Let it be (θ_0, ϕ_0) Then we have

$$\theta^{l}_{k} = \theta_0,$$

$$\phi^{l}_{k} = \phi_0,$$

To bring in Temperature, we suppose that the atoms are vibrating and their axes librating. In addition to Born's translational displacements, we have now

$$\theta^{l}_{k} = \theta_0 + \delta\theta^{l}_{k}; \qquad \phi^{l}_{k} = \phi_0 + \delta\phi^{l}_{k}; \text{ \&c.}$$

Forming the equations of motion the frequencies are to be determined as in Born's articles 17 and 18. [Dynamik der Kristallgitter pp. 585-593.]

Now the (θ, ϕ)—librations reduce the average magnetic moment of the atoms in the direction about which the axes are librating, and frequencies establish a relation with the temperature, whether by the the classical equipartition formula, or by the quantum theory formula.

This is the general method of introducing the effects of Temperature, in ferromagnetic crystals.

The development of the actual algebra for this general method will be postponed for the present. In what follows the assumption of

an existence of a 'monochromatic state' will be introduced, and results obtained. Really speaking, as will be seen, this assumption is not justifiable, but it does help to give some picture of how temperature affects the various magnetic phenomena. Besides, the results obtained give a *qualitative* agreement with experiments.

[4°] *The equation Magnetic state on the assumption of a monochromatic state of libration :—*

To attack the problem of specific heats of solids, "Einstein ging von der Überlegung aus, daβ die Atome eines festen Körpers als Resonatoren betrachtet werden können; dann musβ aber ihre mittlere Energie durch die aus der Strahlungstheorie gewonnene Formel gegeben sein ...... Einstein vernachlässigte zuerst die Koppelungen zwischen den Atomen und schrieb diesen sämtlich dieselbe Schwingungszahl ν zu; dann kommt den 3N Freiheitsgraden eines Grammatoms die mittlere Energie

$$E = 3\,R\,T.\,P.\left(\frac{h\nu}{kT}\right); \quad P\,(x) = \frac{x}{e^x - 1}\,."$$

In *exactly* the same way, as a first approximation the 'coupling' forces between the atoms (or say the 'librators') are now neglected, and one and the same frequency (ν) assumed for all.

Now let as usual,—

μ = magnetic moment of each atom

and θ_0 = maximun amplitude of any one of them for θ-libration.

We put, $\theta = \theta_0 \cos 2\pi\nu t$

and we get,

$$\bar{\mu} = \frac{1}{1/\nu}\int_0^{1/\nu} \mu \cos\theta\, dt$$

$$= \frac{1}{1/\nu}\int_0^{1/\nu} \mu \cos\left\{\theta_0 \cos 2\,\pi\,\nu t\right\} dt$$

$$= \mu \quad J_0(\theta_0)$$

If we are dealing with low temperatures then θ_0 will be small and we can expand the integrand and neglect terms higher than θ_0^2. Now, θ_0 will not be the same for all atoms even if ν is the same (by assumption). The observed effect, therefore, will be to reduce the saturation intensity σ_0 in the ratio $\left(1 - \overline{\theta_0^2}/4\right)$.

Thus

$$\sigma = \sigma_0\left(1 - \overline{\theta_0^2}/4\right).$$

Next, the mean kinetic energy due to libration is (for a single atom),

$$\frac{1}{1/\nu} \cdot \frac{1}{2} A \int_0^{1/\nu} \dot{\theta}^2 dt$$
$$= \frac{1}{4} A (2\pi\nu)^2 \theta_0^2$$

(A = moment of inertia of the atom about an axis $\perp$ to its axis of magnetic moment).

The frequency ν is determined by the equation

$A \ddot{\theta} + \mu (H + H_m) \sin\theta = 0$

Where the atom finds itself in a total field of force $H + H_m$. Replacing $\sin\theta$ by θ to our order of approximation we get, the frequency given by

$2\pi\nu = \sqrt{\mu (H + H_m)/A}$.

Now the mean energy of the librating atom = mean kinetic + mean potential

$$= \tfrac{1}{4} A (2\pi\nu) \theta_0^2 + \tfrac{1}{4} A (2\pi\nu)^2 \theta_0^2$$
$$= \tfrac{1}{2} A (2\pi\nu)^2 \theta_0^2.$$

$\therefore$ The mean energy for N atoms, (each vibrating with a different amplitude), is

$$\tfrac{1}{2} A (2\pi\nu)^2 \overline{\theta_0^2} \times N.$$

By Plank-Einstein's formula we get

$$\tfrac{1}{2} N. A (2\pi\nu)^2 \overline{\theta_0^2} = RT. P \left(\frac{h\nu}{kT}\right)$$

where $P(x) = \dfrac{x}{e^x - 1}$

i. e. $\overline{\theta_0^2} = \dfrac{h/2A\pi^2}{\nu\left(e^{h\nu/kT} - 1\right)}$

and we get

$$\left.\begin{aligned} \sigma &= \sigma_0 \left\{1 - \frac{h/2A\pi^2}{\nu\left(e^{h\nu/kT} - 1\right)}\right\} \\ (2\pi\nu)^2 &= \mu (H + H_m)/A \end{aligned}\right]$$

[5°] *Experimental Evidence:—*

Suppose in the first instance, that we expand the term $e^{h\nu/kT}$, and retain the first term, —— i.e. to say adopt the classical, in place of the Quantum formula for the energy. Then we should get

$$\sigma = \sigma_0 \left(1 - \frac{kT/2A\pi^2}{\nu^2} \right)$$

$$= \sigma_0 \left(1 - \frac{2kT}{\mu(H+H_m)} \right)$$

$$\because (2\pi\nu)^2 = \mu\,(H+H_m)/A$$

Thus we have now

$$\sigma = \sigma_0 \left(1 - \frac{2kT}{\mu \cdot \overline{H+H_m}} \right).$$

This is an unsatisfactory result: For, considering the order of magnitude even roughly, we have

$$k = 1{\cdot}372 \times 10^{-16} \text{ erg/degr.}$$

for iron μ = 10 Weiβ Magnetons

$$= 1{\cdot}8 \times 10^{-20}$$

In Webster's experiments $\left\{ \begin{array}{l} H = 3 \times 10^3 \\ H_m = 6 \times 10^2 \end{array} \right.$ roughly

This means

$$\sigma = \sigma_0 \left(1 - \frac{2\,(1{\cdot}3)\,10^{-16}.\ T}{1{\cdot}8 \times 10^{-20} \times 3 \times 10^3} \right)$$

$$= \sigma_0\ [\,1 - T{\cdot}(10^{-1})\,]$$

This would mean that the temperature must be practically zero for the formula to represent facts. For temperatures over half a degree this would give negative magnetization! But, then, we have the difficulty that at so low temperatures, the classical formula has no application.

The way out of this difficulty is suggested by the following considerations:—

We had

$$\bar{\mu} = \frac{1}{1/\nu} \int_0^{1/\nu} \cos \left\{ \theta_0 \cos 2\pi\nu t \right\} dt$$

and $A\ddot{\theta} + \mu\,(H+H_m)\sin\theta = 0$

In deducing from these, the results:

$$\left. \begin{array}{l} \bar{\mu} = \mu \left(1 - \dfrac{\theta_0^2}{4}\right) \\ \text{and } (2\pi\nu)^2 = \mu\,(H+H_m)/A \end{array} \right\}$$

the assumption was that θ_0 is small. Now the radiation-energy-formula has shown that $\overline{\theta_0^2/4}$ comes very great, and θ_0 cannot be treated as small, and only the first two terms will not do in the expansion of cos $[\theta_0 \cos 2\pi\nu t\,]$.

(*i*) The only way to proceed seems to be to solve the equation

$$\overline{\mu} = \frac{1}{1/\nu} \int_0^{1/\nu} \mu \cos(\theta_0 \cos 2\pi\nu t)dt$$

and $A\ddot{\theta} + \mu(H+H_m)\sin\theta = 0$
to a *greater* approximation.

(*ii*) The assumption of a monochromatic state is not justifiable.

(*iii*) The quantum formula must be adopted.

Recognizing these points, we may proceed to see the general consequences of the theory.

We shall obviously get :—

$$\overline{\mu} = \mu\,(1 - \theta_0^2/4 + \ldots \&c.)$$
$$= \mu\,(1 - \theta_0^2 f(\theta_0^2))$$

and $\nu = F\{(H + H_m), \theta_0\}$

and the equation of magnetic state will be of the form :

$$\left.\begin{aligned} \sigma &= \sigma_0 \left(1 - \overline{\theta_0^2 f(\theta_0^2)}\right) \\ \overline{\theta_0^2} &= \frac{h/2A\pi^2}{\nu\left(e^{h\nu/kT} - 1\right)} \\ \text{and } (2\pi\nu)^2 &= F\{(H+H_m), \theta_0\} \end{aligned}\right]$$

Of course, for small values of θ_0 we have

$$\left.\begin{aligned} \overline{\theta_0^2 f(\theta_0^2)} &= \tfrac{1}{4}\theta_0^2 \\ \text{and} \qquad F &= \mu(H+H_m)/A \end{aligned}\right]$$

Note.—This difficulty about the order of magnitude and the necessity to solve the equation more exactly was noticed too late to correct the whole work. The exact discussion regarding Webster's curves is not possible without actually working out the results. The explanation about Weiβ's curves of his latest experiments, however, holds good, all the same. The modifications will be very slight. Therefore, a very rough argument is given instead, for Weiβ's curves :—

In what follows, will be assumed the following form for the solution of our problem :—

$$\left.\begin{aligned} \overline{\theta_0^2} &= \frac{h/2A\pi^2}{\nu\left(e^{h\nu/kT} - 1\right)} \\ \sigma &= \sigma_0\left\{1 - \overline{\theta_0}^2 f(\overline{\theta_0}^2)\right\} \\ \text{and} \qquad 2\mu\nu &= \sqrt{\mu(H + H_m)/A} \end{aligned}\right\}$$

Call this a "provisional solution".

Webster's curves :—Neglecting the temperature effect, the result obtained in the previous paper to explain Webster's Graph was

$$H \times (I_n)_{max.} = \tfrac{1}{2}\, \alpha \mu I.$$

There (I) was the saturation value, and it was concluded that the right hand side being constant, a rectangular hyperbola was obtained. But as was also pointed out "the actual tables do not give the product $H \times (I_n)_{max.}$ constant. In the case of either crystal it slightly increases with the field (H)......The theoretical formula we have obtained does not account for the slight increase in the value of the product $H \times (I_n)_{max.}$ with increasing (H), nor does it explain the sudden drop......"

It seems now that the cause of the discrepancy is to be looked for in the temperature effect. In the relation

$$\tfrac{1}{2}\alpha\mu I = \text{Const.},$$

we must now write

σ_n for (I_n)

$\sigma_0 \left\{ 1 - \overline{\theta_0^2}\, f\, (\overline{\theta_0^2}) \right\}$ for I

and $\mu_0 \{ \quad$ " $\quad \}$ for μ

and we get

$$H \cdot (\sigma_n)\text{max} = \tfrac{1}{2}\alpha\mu_0\, \sigma_0 \left\{ 1 - \overline{\theta_0^2} f (\overline{\theta_0^2}) \right\}^2$$

$$= \tfrac{1}{2}\alpha\, \mu_0\, \sigma_0 \left\{ 1 - \overline{2\theta_0^2 f\, (\theta_0^2)} \right\} \qquad \text{approx.}$$

From the form of the " provisional solution, " we see that, we get an exact rectangular hyperbola if $\overline{\theta_0^2} = 0$

$$i.\,e. \quad \frac{h/2\,A\,\pi^2}{\nu\left(e^{h\nu/kT} - 1 \right)} = 0$$

$$i.e. \quad T = 0$$

Secondly, if $T = 0$, $\overline{\theta_0^2}$ diminishes as ν increases, — *i.e.* as H increases. *i.e.* the product $H \times (\sigma_n)$ max should go on increasing as H increases. This is borne out by the numbers which Webster gave to us :—

Crystal B			Crystal A		
H	(σ_n)max	H. (σ_n)max	H	(σ_n)max	H (σ_n)max
8310	29·7 *	246807	3640	44·4	161616
7620	34·5	262890	3100	49·1	152210
5530	43	237790	2470	53·3	141642
3500	64	224000	2150	63·4	136310
2030	96·5	195895			

These tables are given in the previous paper.

* The only exception : H rises and the product falls.

2. Weiβ experiments in (1917) [J. de Ph. s^e s.t 7, 1917].
These led to his deducing the result

$$\frac{H+H^m}{T}=\varphi(\sigma) \text{ and independent of T (See next article).}$$

Now, this result can be arrived at from the present theory thus:—
By the " provisional solution "

σ is a function of $\overline{\theta_0^2}$

$$\text{and } \overline{\theta_0^2}=\frac{h/2A\pi^2}{\nu\left(e^{h\nu/kT}-1\right)}.$$

If we retain only the classical term

$$\overline{\theta_0^2}=\frac{kT/2A\pi^2}{\nu^2}=\frac{2kT}{\mu(H+H_m)}$$

$$\therefore\ \sigma \text{ is a function of } \left(\frac{T}{H+H^m}\right).$$

$$i.\,e.\quad \frac{H+H_m}{T}=\varphi(\sigma).$$

Now, as we shall see, the later experiments of Weiβ contradict this result. This means that the Quantum form must be retained.

[6°] *Experiments of Weiβ*:—

In both instances, experiments were made on nickel.

1. The paper of 1917 contains the following-argument. " . . Je definirai dorevanant le champ moleculaire pas, $H_m=-\frac{\partial u}{\partial \sigma}$, u etant l'energie de l'unite de mass de la substance, et la T et σ des deux variables". With obvious notation

$$du=C\sigma d\,T-H_m d\sigma$$

$$\therefore\ \frac{\partial C\sigma}{\partial\sigma}=-\frac{\partial H_m}{\partial T}\quad\ldots\quad(\alpha)$$

Again $dQ=C\sigma dT-(H+H_m)\,d\sigma$

and $\therefore$ dQ/T is a perfect differential . . . &c.

$$\frac{1}{T}\frac{\partial C\sigma}{\partial\sigma}=-\frac{\partial}{\partial T}\left(\frac{H+H_m}{T}\right)\ldots\quad(\beta)$$

From (α) and (β) we get

$$\frac{\partial H}{\partial T}=\frac{H+H_m}{T}$$

$$\text{and }-\frac{\partial C\sigma}{\partial\varphi}=\frac{\partial H_m}{\partial T}=T\frac{\partial^2 H}{\partial T^2}\ldots$$

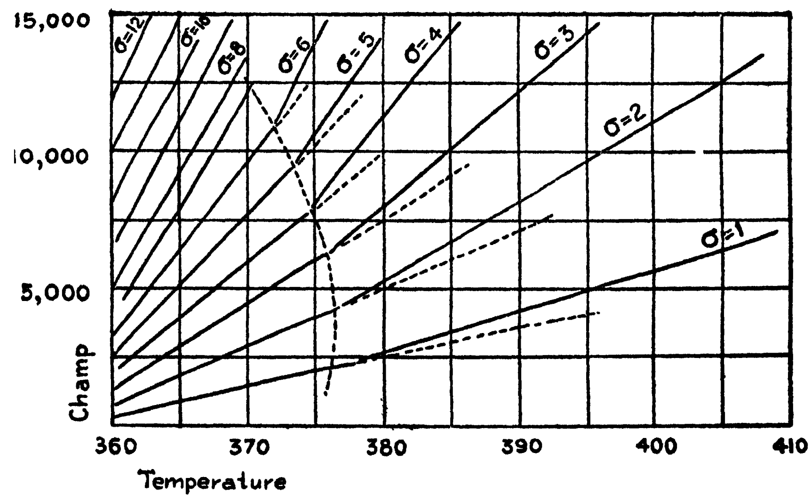
Now, the experimental curves of σ = const. on the (H, T) plane give straight lines

$$\therefore \quad \frac{\partial^2 H}{\partial T^2} = 0$$

$\therefore$ We get

$$-\frac{\partial C\sigma}{\partial \sigma} = \frac{\partial H_m}{\partial T} - \frac{\partial}{\partial T}\left(\frac{H+H_m}{T}\right) = 0$$

$$\therefore \quad \left.\begin{aligned} \frac{H+H_m}{T} &= \varphi_1(\sigma) \\ H_m &= \varphi_2(\sigma) \end{aligned}\right\}.$$



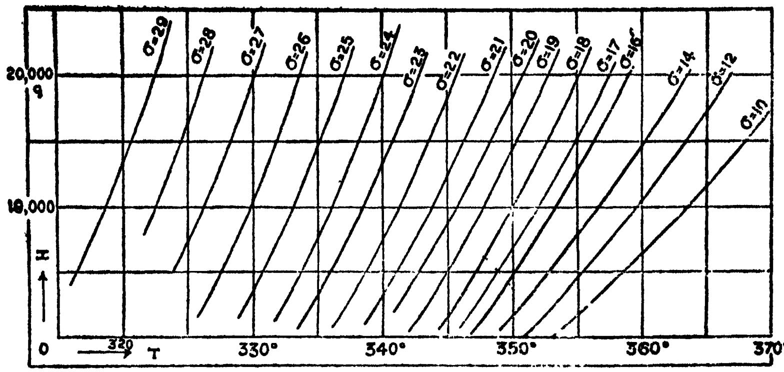
(Exact copy of "fig. 2" page 130 J. de Ph. S[e] 1917)

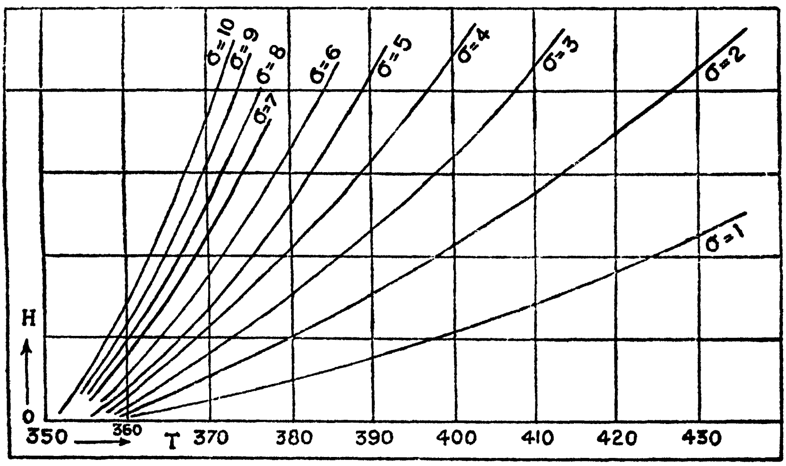
Weiβ observes there, ". . . Mains les droites sont souvent coudées et le lieu des coudes partage le plan en régions dont chacune, il semble plausible de l'admettre correspond à un etat particulier de la materiére.

La relation linéar entre la temperature et le champ, pour une aimantation donnée entraine des consequences thermodynamiques très intéressants". These 'interesting' consequences are the ones mentioned above viz.

$$(H+H_m)/T = \varphi_1(\sigma); \quad H_m = \varphi_2(\sigma).$$

2. On the other hand, the experiments in 1926 yielded curves of a different shape:— [Exact copy from Ann. de Physique Jan.-Fevr. 1926 pp. 206–7].





It is these curves, and their curvilinear character which are referred to by Weiβ in the statement quoted at the very beginning of this paper. Weiβ, further, observes, "Le caractere curviligne des σ = constant, établi au-dessus du Point de curie, n'est donc pas contredit par l'expérience au-dessous de ce point. C'est cette constatation qui oblige à modifier les hypothèses fondamentales pour l'établissement de l'équation d'etat."

It will be shown now that the only 'modification' forced upon us is to accept the experimental result that

$$\frac{\partial^2 H}{\partial T^2} \neq 0$$

Notice, however, three general features about these curves.

(i) All of them if continued down to $T = 0$ will cut the axis of H below the origin.

(ii) The concavity in the case of all curves is away from the axis of T.

(iii) The curves tend to be straight as H increases.

These three features are borne out by the present analysis. Looking to our "provisional solution"

$$\sigma = \sigma_0 \left\{ 1 - \overline{\theta_0^2}\, f\,(\overline{\theta_0^2}) \right\}$$

and $$\overline{\theta_0^2} = \frac{h/2A\pi^2}{\nu\left(e^{h\nu/kT} - 1\right)}$$

We see that the curves $\sigma =$ constant are given by

$$\nu\left(e^{h\nu/kT} - 1\right) = \text{constant (positive)}$$

$$i.\ e.\ h\nu/kT = \log\left(1 + \frac{\text{constant}}{\nu}\right)$$

Writing x for T

and y for $H + H_m$

and substituting $(2\pi\nu)^2 = \mu\,(H + H_m)/A$

We get

$$x = \frac{L\sqrt{y}}{\log\left(1 + \frac{M}{\sqrt{y}}\right)}.$$

where L, M are *positive* constants.

We can write it in the form

$$\frac{x}{y} = \frac{L}{\sqrt{y}\cdot\log\left(1 + \frac{M}{\sqrt{y}}\right)}.$$

Inspection shews that

(i) the curve passes through the origin $x = y = 0$

(ii) $\frac{x}{y}$ increase as y increases. From these two facts it follows that the concavity of the curve is away from the axis of x (*i.e.* T).

Next since $y = H + H_m$, and since the curve passes through (o,o), the effect of taking H only for y is to shift all the curves downwards—*i.e.* to say they will cut the axis y (*i.e.* H) below the origin.

(iii) Observe also that the equation

$$x = \frac{L\sqrt{y}}{\log(1 + M/\sqrt{y})}$$

reduces to $x = \frac{L}{M}\,y$ for large values of y *i.e.* the curves tend to be straight lines as y increases. This is a characteristic which is possessed by the curves in question as given.

S

[7°] *General Remarks*:—

As regards testing the theory quantitatively, we have seen the difficulties; and the question is postponed for the present. In fact the so-called 'monochromatic' formula for the equation of magnetic state does not represent the reality, since we cannot neglect the coupling forces between the atoms. Besides, owing to the discovery of the difficulty about the order of magnitude,—and hence the inadequacy of the approximation,—(which discovery came too late to rewrite the whole paper)—it seemed best to adopt what we have called the "provisional solution". The defects of the provisional solution must be explicitly mentioned here :—

$$\left.\begin{array}{lr}\bar{\mu}=\mu\dfrac{1}{1/\nu}\displaystyle\int_0^{1/\nu}\cos\theta\,dt & \ldots\ (\alpha)\\ \theta=\theta_0\cos 2\pi\nu t. & (\beta)\\ A\ddot{\theta}+\mu\,(H+H_m)\sin\theta=0 & (\Upsilon)\\ \bar{\theta}_0^{\,2}=\dfrac{h/2A\cdot\pi^2}{\nu\left(e^{h\nu/kT}-1\right)} & \ldots\ (\delta)\end{array}\right\}$$

Of this system of equation (α) and (Υ) are exact and will persist in any approximation.

(β) is a solution of (Υ) only to approximation up to θ^2; and in that case

$(2\pi\nu)^2=\mu(H+H_m)\,/A.$

But if this be accepted, then surely we cannot avoid accepting

$\bar{\mu}=\mu(1-\theta_0^2/4)$

Since, if sin θ can be replaced by θ, cos θ must be capable of being replaced by $1-\theta^2/2$. But that leads to an absurd result. Therefore we could not expand cos θ up to $(1-\theta^2/2)$. And hence the relations

$\theta=\theta_0\cos 2\pi\nu t$

and $(2\pi\nu)^2=\mu\,(H+H_m)/A$

are not valid for the approximation required.

And hence the provisional solution is defective,—as it is a mixture of two degrees of approximation. Yet, it is hoped that the main argument will remain unaltered, even when the exact solution is obtained.

[8°] *Hysteresis*:—

The concept of 'libration' gives the following picture of hysteresis.

Suppose we start from the un-magnetized state. The atomic axes are pursuing a random rotary motion (as in Langevin's theory),

or are possibly librating about several directions symmetrically situated, (as seems proper in the case of crystals); that is to say the motion is general but only a superposition of several definite frequencies determined by the crystal structure and the coupling forces. The point is that there is no privileged direction. Introduce a field H. This establishes such a direction. The general motion of 'libration at random' begins to be modified, and the atomic axes tend to librate about this direction more and more. The body thus shows a tendency to magnetization. As H increases, the frequency of libration increases, the maximum amplitude diminishes (if T is to remain the same), and consequently the average moment of the atom in the direction of the libration-axis increases. This causes increase in the magnetization (σ).

Now suppose the field H is removed. This removal does not change librations into random motion at once. There is the field H created in the process of magnetization. That still persists. The effect of removing H is simply to decrease the frequency, and hence to increase the amplitude (if temperature is to remain the same), and thus diminish the magnetization. If H_m is strong enough a point will be reached when H_m is sufficient to maintain the librations without further decrease in the frequency. The corresponding magnetization will remain, and the body will behave as a permanent magnet ever afterwards. *That is Hysteresis.*

If, on the other hand, H_m is not sufficiently strong, the decrease in frequency will soon bring about a state when the atoms, one after another, begin to break away from the libratory motion, to lapse into a random motion. This reduces (σ); and consequently H_m also diminishes. In this way the process once started, gets accelerated, and in the later stages, the magnetization dies away quickly. This again explains the lag of (σ) behind (H). The time taken by the body to return to the unmagnetized state will of course depend upon its structure and the nature of the constituent atoms.

[9°] *Conclusion :—*

1. It is suggested that the concept of temperature can be brought in the theory of Ferromagnetism by means of libration frequencies. The method requires to be fully worked out by means of a polychromatic formula. The 'monochromatic,' formula which is worked out gives absurd quantitative results, *if only the first approximation is taken.* The exact form of the solution explains *qualitatively* the results of Weiß's latest experiments. It may be that this way of introducing temperature will not answer the facts. But almost all extant theories on magnetism have been unsatisfactory. And it is as yet too early to say whether this method will or will not work.

2. The recent experiments on the specific heat of Ferromagnetic Substances do not agree with Weiβ theory of the same (cf: quotation at the beginning of this paper);—it seems very likely that a satisfactory theory can be worked out on the present lines—i. e., by adopting Born's way and introducing in addition, librational frequencies.

Note 1.—Mckeehan's suggestion that magnetization must proceed discontinuously in space as well as in time assumes, as he himself admits that there is a slight inhomogeneity in the matter. Now we are here trying to build a working theory for a crystal. And thus the argument of inhomogeneity can scarcely hold good.

On the other hand even in the regular structure of crystals quantum processes will introduce discontinuities, due to the sudden jumps of electrons from one stationary orbit to another, the magnetic moments of atoms will suddenly change. This possibility is never denied. But it is so difficult to take account of it mathematically. In that case the only change in our statement will be:—

"Let μ = *average* moment of the atom for a long time."

Again, there is no reason why the assumption of groups should be opposed to atomic processes, as far as the observable phenomena are concerned. The sub-atomic process may not admit of 'groups-assumption.' But when once that is got over by putting

μ = *average* moment ... &c.,

the groups-assumption can well be introduced, if required.

Note 2.—Alternative formula for the equation of state.

[1°.] We shall follow Livens' method, p. 392 but we must take account of the following three points of difference:—

(a) In Livens' case the magnetic potential energy is put down as

$$-\mu\ B\ [\ A\ \dot{\phi}\ \sin^2\theta + C\ \cos\theta\ (\dot{\psi} + \dot{\phi}\cos\theta)\ ].$$

Here each charged particle is separately considered, and on account of the gaseous state collisions are not excluded.

In *our case*, on the other hand, our magnetic molecules (or elementary magnets) are so to say fixed at the lattice-points. Each of these is a complex structure, but is now treated as a magnet with moment μ. The individual motions of the orbital electrons are not taken any notice of;—and hence the molecule as a whole has the magnetic energy $-\mu H\cos\theta$. We may suppose that our magnetic molecule is somewhat like an elongated ellipsoid of rotation.

For a Ferromagnetic molecule, μ is fairly great to be sensibly regarded as constant.

$\therefore$ *Instead of Livens'* expression we adopt

$-\mu H \cos\theta$ for the potential energy.

[The justification for assuming the above model is—" .. Man kann somit out eine langgerstreckte from der Elementar magnete schlieβeu, deren länge sich aber vorerst richt abschätzen läβt. Auch sprechen diese Versuche zugunsten der Hypothese, da β im "magnetisch reinen Eisen" die Elementamagnete vorcebildst sind, . . . v". Gerlash.].

(b) It is easily seen that in our case, $E \equiv T+V$ is *conserved.*

(c) Thirdly, we assume that the 'ellipsoidal' magnets have no spin about their axes.

$$i.e.\ n \equiv \dot{\psi} + \dot{\phi}\cos\theta = 0$$

[2°] Thus in our Ferromagnetic case the problem becomes

$$\left.\begin{array}{l} T = \tfrac{1}{2} A\ (\dot{\theta}^2 + \sin^2\theta\dot{\phi}^2) \\ V = -\mu H \cos\theta. \\ \text{where } H = \textit{total} \text{ field present.} \end{array}\right\}.$$

Now following Livens we have

$$\Theta = \frac{\partial L}{\partial\dot{\theta}} = A\dot{\theta}$$

$$\Phi = \frac{\partial L}{\partial\dot{\phi}} = A\sin^2\theta\,\dot{\phi}.$$

$$\therefore\quad E = \frac{\Theta^2}{2A} + \frac{\Phi^2}{2A\sin^2\theta} - \mu H\cos\theta.$$

With obvious notation

$$dn = \alpha e^{-E/kT} d\Omega$$

$$d\Omega = \sin\theta d\theta\, d\phi.\, d\Theta.\, d\,\Phi\,.$$

α is determined from

$$n = \alpha \int e^{-E/kT} d\Omega.$$

Now obviously we get the magnetization per unit volume as

$$\sigma = \frac{n\mu \displaystyle\int\!\!\int\!\!\int\!\!\int \cos.\theta \cdot e^{\left\{\mu H.\cos\theta - \frac{\Theta^2}{2A} - \frac{\Phi^2}{2A\sin^2\theta}\right\}/kT} .\sin\theta d\theta d\phi d\Theta d\Phi}{\displaystyle\int\!\!\int\!\!\int\!\!\int e^{\left\{\ \cdot\ \cdot\ \cdot\ \cdot\ \right\}/kT} \sin\theta.d\theta.d\phi d\Theta d\Phi.}$$

Now the integrations with respect to ϕ and Θ simply cancel out from the numerator and denominator, and we are left with,

$$(\because n\mu = \sigma_0, \text{ saturation}).$$

$$\sigma = \sigma_0 \frac{\int\int \text{Cos}\,\theta . e^{\left\{\mu \text{ H} \cos\theta - \frac{\Phi^2}{2 \text{ A} \sin^2\theta}\right\}/k\text{T}} \sin\theta \, d\theta \, d\Phi .}{\int\int e^{\left\{\mu \text{ H} \cos\theta - \frac{\Phi^2}{2 \text{ A} \sin^2\theta}\right\}/k\text{T}} \sin\theta \, d\theta . d\Phi}$$

[If we were to put $\Phi=0$, we get back to Langevin's case].

As in Langevin's case the limits for θ may be taken as 0 to π.

Then putting x as $\cos\theta$, we get :—

$$\sigma = \sigma_0 \frac{\int_{-1}^{+1} dx \int d\Phi \left[x \, e^{\left\{\mu \text{ H}x - \frac{\Phi^2}{2\text{A}(1-x^2)}\right\}/k\text{T}} \right]}{\int_{-1}^{+1} dx \int d\Phi \left[e^{\left\{\mu \text{ H}x - \frac{\Phi^2}{2\text{A}(1-x^2)}\right\}/k\text{T}} \right]}$$

We take the limits for Φ to be $-\infty$ to $+\infty$. For, as

$\Phi = \text{A} \sin^2\theta \, \dot{\phi}$, there is nothing geometrically impossible for $\dot{\phi}$ to be very large.

Now carrying out the integrations with respect to Φ first, and using

$$\int_{-\infty}^{\infty} e^{-\alpha^2 x^2} dx = \sqrt{\pi}/\alpha, \text{ we get}$$

$$\sigma = \sigma_0 \frac{\int_{-1}^{+1} dx \cdot x e^{\mu \text{H}x/k\text{T}} \times \sqrt{2\text{A}(1-x^2)/k\text{T}} \cdot \sqrt{\pi}}{\int_{-1}^{+1} dx \; e^{\mu \text{H}x/k\text{T}} \sqrt{2\text{A}\;(1-x^2)/\text{T}} \sqrt{\pi}}$$

$$\textit{i.e. } \sigma = \sigma_0 \frac{\int_{-1}^{+1} x \sqrt{1-x^2} \; e^{\mu \text{H}x/k\text{T}} dx}{\int_{-1}^{+1} \sqrt{1-x^2} \; e^{\mu \text{H}x/k\text{T}} dx}$$

Note :—This formula for Ferromagnetism differs from Langevin's for Paramagnetism in three respects :—

(i) presence of the extra factor $\sqrt{1-x^2}$

(ii) σ_0 ($=n\mu$) is much greater for a Ferromagnetic substance.

(iii) in $e^{\mu H/kT}$, H = H external + H internal.

The internal H may be put equal to Nσ following Weiβ ;—or equal to N$f(\sigma)$ more generally. [$f(\sigma)$ an odd function].

It is to be noticed that the final result comes out independent of A.

DISCONTINUOUS FLUID MOTION

By

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The general equations of motion of a fluid, when its viscosity and compressibility are neglected, were discovered by Lagrange and Euler. But it was found that some of the results according to this theory—the so-called classical Hydrodynamics—are in complete disagreement with observed results, even in the case of fluids like water whose viscosity is very small and was considered unimportant. So much so that practical people were doubtful as to whether there was any relation between theoretical Hydrodynamics, and the actual behaviour of fluids.

Some of these surprising results may be mentioned. According to this theory, a body exposed to a stream of perfect fluid would experience no resultant force at all, any pressure on its face being compensated by equal and opposite pressure on its rear. A particular case of this viz. when the body is a sphere was first solved by Dirichlet and is known as "Dirichlet's paradox."

According to the classical theory the form of flow about a symmetrical body is the same behind as in front. This is quite different from what is observed in actual practice. If a flat plate is held fixed in moving water, the liquid refuses to close in behind, and a region of more or less "dead-water" (*i.e.* still water) is formed, entailing a large resistance.

Thirdly, according to theory, the velocity of the fluid at the sharp edge of an obstacle should become infinite. In practice the velocity is very great to start with, but speedily diminishes owing to the formation of an eddy.

Fourthly, the classical theory would involve negative pressure in a fluid. Rayleigh remarks that there is nothing in the constitution of a perfect liquid to prevent the existence of negative pressure. But in actual practice it is not observed in the cases, where according to the classical theory it should occur.

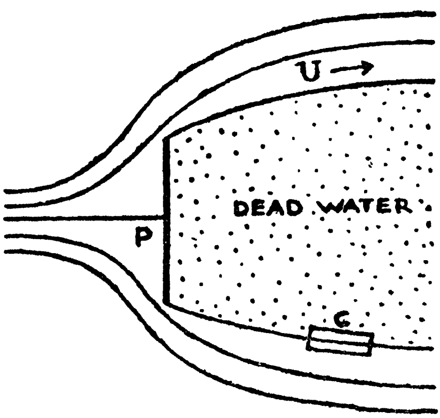
It is clear therefore that some alteration is necessary. If we take viscosity into account, the problem becomes too hard. No general solution of the equations for a viscous fluid has yet been given, though particular cases have been solved. The scientist therefore still kept the assumption of a perfect liquid.

It was Helmholtz who first pointed out that there was nothing in the nature of a perfect fluid to forbid a finite slipping between con-

tiguous layers and that the possibility of such an occurrence was not taken into account in the common theory.

To make clear the improvement effected by this theory let us consider the case of a flat plate moving in still water. This was solved by Kirchhoff and discussed more fully by Rayleigh (Two dimensional motion).

FIG. 1.



The fluid behind the plate is supposed to move strictly with the advancing plate and to be separated from the main fluid by a surface of separation. The tangential velocities on the two sides of the surface are different. There is no velocity normal to the surface.

If the plate be assumed fixed and the fluid to flow about it, the fluid behind the plate is at rest under a pressure equal to that which prevails at a distance. The surface of discontinuity is determined mathematically by condition of constant pressure (equal to the pressure in the "dead-water" region).

If p is the pressure and u the velocity at a distance, and ρ the density of fluid, the pressure at the middle-point of the front side of the plate is by Bernoulli's equation $p+\frac{1}{2}\rho u^2$ (since at this point the liquid comes to rest). The pressure on the rear side is p. If the liquid were to come to rest at all points on the front side, we should get the total resistance equal to

$$\tfrac{1}{2}\,\rho u^2 \times \text{the area of the plate.}$$

This is only an approximation. The liquid does not come to rest at all points of the plate, and more exact theory gives the total resistance equal to

$$\frac{\pi}{4+\pi}\,\rho u^2 \times \text{the area of the plate.}$$

$$\left(\frac{\pi}{4+\pi}=0{\cdot}44 \text{ approx.}\right)$$

Experimentally, the resistance is found to be about $\rho u^2 \times$ area of the plate, *i. e.* more than twice as great as the theoretical value.

The reason for this disagreement between the theoretical and the experimental values is this. In practice the pressure just behind the plate is not equal to, but less than p the pressure at a distance. This cannot be taken into account in Kirchhoff's theory.

But the new theory is a great improvement on the older one, which did not give any resistance at all. At the edges the new theory does not give infinite velocity. It does not give rise to negative pressu res, and the form of the flow according to this theory agrees better with experiment than the form of flow according to the older theory did.

Let us now consider some of the objections that have been raised against this theory. Lord Kelvin objected that the motion was contrary to the "minimum energy theorem" (called after him). As Lanchester points out this objection has no force. For the minimum energy theorem assumes the absence of discontinuity, and when the assumption is rejected, Kelvin's theorem does not hold.

A second objection put forward by Kelvin was that such a surface of discontinuity would be unstable. This objection is perfectly valid and explains why in practice such a surface is not observed. There is no sharp dividing line between the main flow and the "dead water" region.

A third objection is the existence of circulation along the rectangular curve C (see figure 1). By Kelvin's theorem circulation along a closed curve moving with the fluid (assumed incompressible and non-viscous) does not change. As there was no circulation at a distance in front of the plate, it is argued that it is not possible to have circulation behind. On the other side it is argued that this circulation is due to viscosity, and that though in an inviscid fluid, the circulation could not occur, the objection does not hold for a fluid with small viscosity. The argument is incorrect. For though it is possible to generate circulation in the viscous fluid, yet *quantitatively* the existence of so much circulation in a fluid with negligible viscosity cannot be explained.

The error in the objection was discovered very late. Kelvin's theorem applies to curves moving with the fluid. The curve C has not moved with the fluid. The lower portion has come with the main portion of the fluid, while the upper portion has always been there. Hence before some time the particles forming the upper and the lower portions respectively were separate, and the two together did not form a closed curve.

It has been mentioned that the theoretical form of flow does not agree well with the observed. It is assumed in the theory that with respectto a co-ordinate system moving with the body, the flow is stationary, which is certainly not true.

According to the theory there is no "suction" behind the body, because in the dead-water region the pressure is constant and equal to the pressure at a great distance from the body. But experiment shows that this suction has a great influence on the resistance experienced by the body.

The reason why the hydrodynamically possible discontinuous potential flow does not exist, lies in the instability of the surface of discontinuity. (See above)

One can think of the surface of discontinuity as a "vortex-layer." This vortex-layer shows a tendency to "curl," *i. e.* the vorticity is concentrated at some points and taken away from the region between these points. This observation suggests that there may be stable arrangements of isolated vortices, which can be regarded as the end-product of the vortex-layer.

Such an arrangement was found by Kármán, called Kármán vortex-street after him. By assuming the existence of such an arrangement behind the body Kármán calculated the resistance on a cylinder (two-dimensional flow). He found it equal to $\rho\zeta \frac{h}{l}(U-2u) + \rho \frac{\zeta^2}{2\pi l}$ where ρ is the density of the fluid, ζ the vortex strength, U the velocity of the body relative to the fluid, u the velocity with which the vortex-system moves forward relative to the fluid, h is the distance between the two rows, and l the distance between two adjacent vortices of the same sign (see Lamb, p. 211 for a fig. of the stable arrangement). The calculated resistance agrees very well with the observed.

The stability consideration gives

$$\text{Cosh } \frac{h\pi}{l} = \sqrt{2} \quad i.\ e.\ \text{Sinh } \frac{h\pi}{l} = 1$$

$$i.\ e.\ \frac{h}{l} = 0{\cdot}281 \text{ approx.}$$

$$u = \frac{\zeta}{2l} \tanh \frac{\pi h}{l}$$

Hence two of the quantities have to be determined by experiment, u and l say. In this respect Kármán's theory is not complete, for when the size and shape of the cylinder and the velocity of the cylinder relative to the fluid, are given, it is not possible to calculate the resistance without measuring two quantities.

Heisenberg (Physik. Zeit. 1922) has tried to obtain the resistance on a flat plate moving normally through a fluid. He assumes that the flow is a discontinuous potential flow to start with, but later degenerates into a Kármán vortex-street, whose dimensions he has found out from purely theoretical considerations. The results agree well with experiment. It remains now to see how the surface of discontinuity resolves itself into the stable arrangement of the Kármán vortex-street. This problem has not been solved. But Rosenhead (in P.R.S. 1928) has proved that a plane surface of discontinuity degenerates into a row of periodically distributed vortices of the same sign.

Summary:—We have seen how the continuous potential flow did not agree well with experiment. It was modified by Helmholtz who assumed that a surface of discontinuity could occur. We have seen the objection to this, firstly that the surface is unstable, and secondly, the resistance given by it is much less than the experimental value. We have seen that Kármán and Heisenberg have found theoretical values which agree very well with experiment, and lastly we have a proof by Rosenhead that a surface of discontinuity does actually resolve into a vortex-row.

APPENDIX

Reference has been made to papers by Kármán and Heisenberg A more detailed description of the two papers will be given here.

Kármán:—"Uber den Mechanismus des Flüssigkeits-und Luft-widerstandes". (Physik. Zs. 1912)

If we assume that at some distance behind the body the flow does not differ appreciably from the flow due to the stable vortex arrangement, and that at some distance in front of the body (the distance is large compared to the linear dimensions of the body), the fluid is at rest, then we obtain an expression for the resistance by the application of the Impulse Theorem.

We use the co-ordinate system which moves with the vortex system (which moves forward with velocity $u \equiv \frac{\zeta}{2l} \tanh \frac{\pi h}{l}$ with respect to the fluid at rest, $\zeta \equiv$ Vortex strength). With respect to this co-ordinate system, on the assumptions we have made, the flow is stationary at some distance in front as well as behind the body. In front there is uniform flow with velocity $-u$, behind the body the velocity components are $-u + \frac{\partial \Psi}{\partial y}$ and $-\frac{\partial \Psi}{\partial x}$ where

$$X \equiv \phi + i\,\Psi = \frac{i\zeta}{2\pi} \log \frac{\sin(z^0 + z)\frac{\pi}{l}}{\sin(z^0 - z)\frac{\pi}{l}} \quad \left(\text{where } z^0 \equiv \frac{l}{4} + \frac{hi}{2}\right)$$

X is due to the vortex system at rest. (See Lamb.)

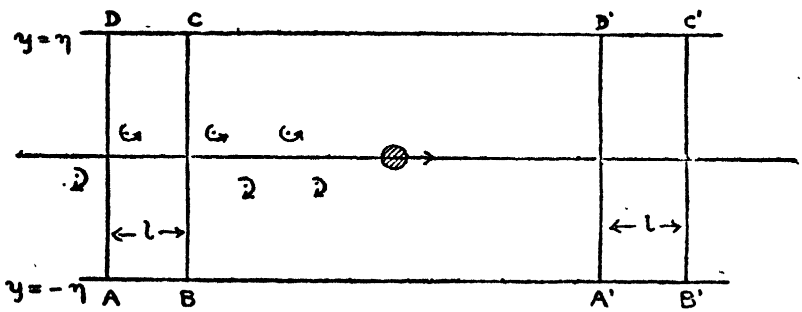
Relative to our co-ordinate system, the body moves with velocity U-u, where U is its actual velocity. In time $T = \frac{l}{U-u}$ (l is the distance between two consecutive vortices of the same sign) a new pair of vortices is formed. We calculate the increase of x-impulse in this time T (*i. e.* between two instants of time after which the flow pattern is exactly the same as before) in the following region:—We take two parallels $y = \pm\, \eta$. and two parallels x = const. in front and behind the body at a great distance from the body. The line behind the body

is so chosen that it is exactly in the middle of two vortices of opposite sign.

For a region so chosen the impulse exerted on the body $\int_0^T W\,dt$ (where W is the resistance) is equal to $\Big[$ the difference of impulse in the region at time $t=\tau$ and $t=\tau+T \Big] - \Big[$ the impulse imported from outside $\Big] + \Big[$ the time integral of the pressure on the boundaries of the region $\Big]$.

We shall calculate the quantities one by one. The increase in impulse in time T = increase in $\int\int \rho\, u\,(x,y)\,dxdy$. But the interval

FIG. 2



T is so chosen that the flow pattern reproduces itself exactly with the exception that the body has moved forward $l = (U-u).T$.

The whole double integral reduces to the difference of the integrals on the regions ABCD and A′B′C′D′, both of breadth l.

For A′B′C′D′, the x - component of the velocity is $-u$, and for ABCD it is $-u+\dfrac{d\Psi}{dy}$

$$\therefore \text{ The whole quantity } I_1 = \rho \int_0^l \int_{-\eta}^{\eta} \frac{d\Psi}{dy}\,dx\,dy.$$

If we take limit $\eta \to \infty$, then we obtain

$$I_1 = \rho\zeta h.$$

The sum of the imported impulse and the time integral of pressure will be taken together.

If we take any potential flow $u\ (x.\ y)$, $v\ (x.\ y)$ and consider a certain region, then the x-impulse imported per sec $=\rho\int(u^2dy - \bar{u}\,\bar{v}\,dx)$, where $\bar{u}$, $\bar{v}$ are the velocity components on the boundary. The pres-

sure gives, for x-component, $\int \bar{p}\ dy$. By Bernoulli, in stationary potential flow $\bar{p}$ = const $- \rho \frac{\bar{u}^2+\bar{v}^2}{2}$ $\therefore$ The sum of both integrals (multiplied by time T) is

$$I_2 = T\left\{ \int \rho\left(\bar{u}^2\,dy - \bar{u}\,\bar{v}\ dx\right) + \int \bar{p}\,dy \right\}$$

$$= T\,\rho \int \left[\frac{\overline{u^2-v^2}}{2}\,dy - \overline{uv}\ dx\right]$$

or if we introduce $\bar{w} = \bar{u} - i\bar{v} = \frac{\partial \chi}{\partial z}$

$$I_2 = \frac{T\rho}{2}\ Im\left(\int \bar{w}^2\ dz\right)$$

where Im denotes that the imaginary part is to be taken.

On the boundaries we put $\bar{u} = -u + u'$, $\bar{v} = v'$ then the terms in u^2 disappear; the terms in u also disappear by continuity (the incoming fluid = the outgoing fluid), and only the terms in u'^2, $u'\,v'$ remain. This gives a value on the line which goes through the vortex-system (AD in fig.).

If we let $\eta \to \infty$, then

$$I_2 = \frac{T\rho}{2}\ Im\ \left\{\int_{-i\infty}^{i\infty} \left(\frac{\partial\chi}{\partial z}\right)^2 dz\right\}\ \text{along AD}$$

$$= \frac{T\rho}{2}\ Im\ \left\{\int_{\chi(-i\infty)}^{\chi(i\infty)} \frac{\partial\chi}{\partial z}\ d\chi\ \right\}\text{along AD}$$

$$= T\rho\ \left\{\frac{\zeta u h}{l} - \frac{\zeta^2}{2\pi\ l}\right\}$$

$$\therefore \int_0^T W dt \quad = \rho\,\zeta\,h - T\rho\left(\frac{\zeta\,u\,h}{l} - \frac{\zeta^2}{2\pi\ l}\right)$$

If we put $\bar{w}$ instead of $\frac{1}{T}\int_0^T w\ dt$, then since $T = \frac{l}{U-u}$

$$\bar{w} = \rho\,\zeta\,\frac{h}{l}\left(U - 2u\right) + \rho\,\frac{\zeta^2}{2\pi\ l}$$

W. Heisenberg "Dimensions of the Karman Vortex-motion"

Figure 1 (already given) represents the flow (2-dimensional) about a plate of length d (kirchhoff's discontinuity flow). It is the only known flow for which the velocity at the end of the plate remains finite. The shaded portion behind represents the "dead-water", and the lines bounding the portion the curves of discontinuity.

These curves are known to be unstable. We assume that very near the plate the curves of discontinuity exist, and that they break up at some distance behind. This assumption is justified on experimental grounds.

Let U be the velocity of the plate relative to the water (assumed to be at rest at ∞) and let u be the velocity of the vortices. Then relative to the vortices, the velocity of the plate is $U - u$. Let l be the distance between two successive vortices of the same sign. Then $T = \dfrac{l}{U - u}$ is the period, or the time between the shedding of two successive vortices of the same sign. If ζ is the strength of each vortex, then if we consider the upper row of the " Karman vortex-street " only (assumed to arise from the breaking up of the upper surface of discontinuity) ζ is the increase of circulation in time T or ζ/T

$$\text{per unit time} = \frac{\zeta}{l}(U-u) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

In the dead-water the velocity is zero. Outside the velocity is U.

$\therefore$ The curve of discontinuity itself moves with velocity $\dfrac{U}{2}$.

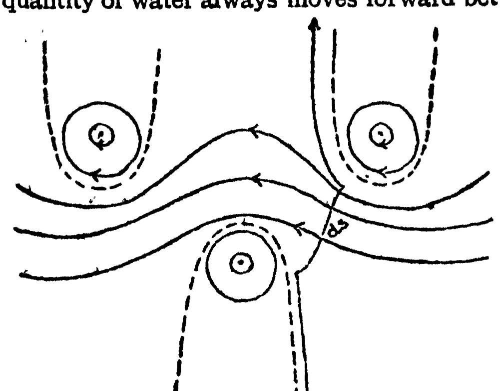
$$\therefore \text{ Length of curve generated per unit time} = \frac{U}{2}. \quad . \quad . \quad . \quad (2)$$

$$\therefore \text{ Circulation generated per unit time} = U\frac{U}{2} \quad . \quad . \quad . \quad . \quad (2)$$

Since in an incompressible frictionless fluid the circulation remains unaltered, the two expressions (1) and (2) must be equal.

$$i.e., \ \frac{U^2}{2} = \frac{\zeta}{l}(U - u). \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

Another equation is obtained from the fact that a certain fixed quantity of water always moves forward between the two vortex rows. (Outside the vortex rows a particle does not move very far from its original place. But inside, it is continually moving.)



This quantity of water $\equiv$ the water pushed forward by the plate $= U.d.$

According to Karman the complex potential of the " vortex street " is

$$\chi = \frac{i\zeta}{2\pi} \log \frac{\sin\,(z^0 - z)\,\frac{\pi}{l}}{\sin\,(z^0 + z)\,\frac{\pi}{l}} \quad \ldots\ldots\ldots\ldots \quad (4)$$

where $z^0 = \frac{l}{4} + \frac{hi}{2}$

Q the quantity of water $= \int_a^b \mathrm{U}_n\, ds = \int_a^b \mathrm{I}\,(\mathrm{W}dz)$

where I $\equiv$ imaginary part and $\mathrm{W} = u - iv = \frac{d\chi}{dz}$

$$\therefore\ \mathrm{Q} = \mathrm{I}\int_a^b \frac{d\chi}{dz} dz = \mathrm{I}\int_a^b d\chi = \Big[\mathrm{I}\,(\chi)\Big]_a^b$$

The terminii a, b of the integral must lie on the stream lines—the boundaries of the required water flow. The exact position of a, b on the stream-lines does not matter. In the present case, the boundary stream-lines are the only ones which $\rightarrow\infty$ in the Y directions. $\therefore a = -i\infty$; $b = +i\infty$ may be chosen. The path of integration is from $z = -i\infty$ along the stream line till we come near the vortex, then along ds. and then along the other boundary stream line to

$z = +i\infty \quad \therefore \quad \mathrm{Q} = \mathrm{I}\left(\chi_{+i\infty} - \chi_{-i\infty}\right)$

Now by (4)

$$\chi_{\alpha+\beta i} = \frac{i\zeta}{2\pi} \log \frac{e^{i\frac{\pi}{l}\left(\frac{l}{4}+\frac{hi}{2}-\alpha-\beta i\right)} - e^{-\frac{i\pi}{l}\left(\frac{l}{4}+\frac{hi}{2}-\alpha-\beta i\right)}}{e^{\frac{i\pi}{l}\left(\frac{l}{4}+\frac{hi}{2}+\alpha+\beta i\right)} - e^{-\frac{i\pi}{l}\left(\frac{l}{4}+\frac{hi}{2}+\alpha+\beta i\right)}}$$

For $\beta\rightarrow\infty$, $\alpha = 0$ (α does not appear in the imaginary part of χ).

$$\chi_{+i\infty} = \frac{i\zeta}{2\pi} \log \left(-e^{\frac{i\pi}{2}-\frac{h\pi}{l}}\right) = -\frac{3\zeta}{4} - \frac{i\zeta h}{2l}$$

$$\chi_{-i\infty} = \frac{i\zeta}{2\pi} \log \left(-e^{-\frac{i\pi}{2}+\frac{h\pi}{l}}\right) = -\frac{\zeta}{4} + \frac{i\zeta h}{2l}$$

Hence $\left|\ \mathrm{I}\left(\chi_{+i\infty}\right) - \mathrm{I}\left(\chi_{-i\infty}\right)\right| = \frac{\zeta h}{l} \quad \ldots\ldots \quad (5)$

$\therefore\ \mathrm{U}d = \mathrm{Q} = \frac{\zeta h}{l} \quad \ldots\ldots\ldots\ldots \quad (6)$

Karman gives $\frac{\zeta}{l\sqrt{8}} = |u \quad \ldots\ldots\ldots\ldots \quad (7)$

$\frac{h}{l} = 0{\cdot}281 \quad \ldots\ldots\ldots\ldots \quad (8)$

From (3) $\frac{1}{2}\mathrm{U}^2 = u\sqrt{8}\,(\mathrm{U}-u)$.

$$i.e.\ 1 = 2\sqrt{8}\,\frac{u}{U}\left(1 - \frac{u}{U}\right)$$

gives $\quad \dfrac{u}{U} = 0{\cdot}229 \quad \ldots\ldots\ldots\ldots \quad (9)$

or $\quad \dfrac{u}{U} = 0{\cdot}771 \quad \ldots\ldots\ldots\ldots \quad (9a)$

From (6), using (7) and (8).

$$Ud = u\sqrt{8}\cdot l\cdot(0{\cdot}281).$$

using (9) $\dfrac{l}{d} = \dfrac{1}{\sqrt{8}\,(0{\cdot}281)\,(0{\cdot}229)} = 5{\cdot}45 \quad \ldots\ldots \quad (10)$

$$\frac{h}{d} = 1{\cdot}54 \quad \ldots\ldots\ldots\ldots \quad (11)$$

(9*a*) gives a much smaller value for $\frac{l}{d}$ and $\frac{h}{d}$, but as the curves of discontinuity are inclined outwards this possibility cannot be realised. Karman gives as empirical values.

$$\frac{u}{U} = 0{\cdot}20\ ;\ \frac{l}{d} = 5{\cdot}5.$$

The resistance also agrees well with experiment.

*RELATIVITY AND COSMOLOGY—PART I

By

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INTRODUCTION.

I should like, in the very first instance, to express my most sincere thanks to the University of Bombay for their kind invitation to give this course of lectures. I am alive to the honour they have done me thereby and incidentally to the responsibility that rests on my shoulders in return.

I did not want to lecture on relativity alone as the subject has of late gone into a rut. Moreover it has lost, in a relative sense, the glamour it had during the first few years after the war. On the other hand the subject of cosmology is centuries old. Men in almost every walk of life, philosophers of almost every shade of opinion have indulged in the very fascinating game of speculating on the origin of the universe. Cosmology is, therefore, a vast subject and I know nothing of its extension in the strictly philosophical domain. I have therefore decided to give a short account of certain principles of relativity that would facilitate a smooth entry into the domain of cosmology.

The relativistic treatment of cosmology is fascinating from the stand-point of sheer mathematics. It has a number of problems that look as if they can be easily solved and yet have defied the attacks of some of the most eminent mathematicians, past and present. It is an excellent field for the research students who are hunting after problems and I have therefore chosen this for my subject.

The Theory of relativity can be studied from four different points of view: (1) Gravitational astronomy, (2) Geometry, (3) Electrodynamics, and (4) Philosophy.

Let us now consider how the need for the theory of relativity arose from the standpoint of gravitational astronomy.

The three laws of Kepler concerning the motions of the major planets about the sun are very well-known. Newton deduced from them the law of gravitation which has achieved such remarkable success not only in the solar system but in all the regions of space that have been so far explored. According to the first law of Kepler each planet

***This is a report of six lectures delivered on the subject in January 1933 by Prof. V. V. Narlikar under the auspices of the University of Bombay.**

moves in an ellipse of which a focus is at the sun. The second says that the radius vector from the sun to the planet describes equal areas in equal intervals of time, while the third is that the square of the periodic time varies as the cube of the mean distance. It is true that the planets move in a rough sort of way so as to be subject to these laws. But if we take the Newtonian law of gravitation as fundamental and Kepler's empirical laws as the consequences of the former then the motion of any planet is perturbed owing to the gravitational attraction of the other planets in the solar system. Thus Newcomb[1] has shown that one result of perturbation in the case of the Mercury is that the ellipse of Mercury itself rotates about the sun at the rate of $532''$ per century. But it has been observed that the rotation is approximately $575''$ a century i. e., $43''$ per century more. On the Newtonian hypothesis no satisfactory explanation of this extra rotation could be given. Several attempts were made to account for these extra $43''$ per century but to no success and it was ultimately left to the theory of relativity to explain the phenomenon. We will come to these considerations later on but it ought to be remarked here that the success of the theory of relativity in this particular is attributed more to chance than to any intrinsic merit in the latter.

An interesting position presents itself at this point. Kepler's objection to the geocentric theory of the universe in which the planets moved in cycles and epicycles was that it could not account for some $8'$ in the revolution of Mars. Thus the Newtonian theory arises out of the $8'$ of Mars while Einstein's theory arises out of the $43''$ of Mercury. One expects that an improvement on Einstein could emanate only out of a still more subtle phenomenon.

Next consider the approach to relativity from the geometrical point of view. Before the advent of the theory of relativity it was customary to use Euclidean geometry for the exploration of all the fields of physics. That the parallels meet at infinity, which is an axiom of Euclidean Geometry is certainly contrary to common experience; and it has therefore to be taught at school as that ultimately, it becomes assimilated into ones habit of thought. As it is beyond the scope of our observation we may with equal justification say that parallels meet at any distance of the order of 10^{10} miles. If therefore our space is not subject to the Euclidean geometry the possibility arises that the empirical laws of physics which hold good in our neighbourhood may not do so for the large-scale phenomena. Now cosmology is concerned with such large-scale phenomena and it is therefore necessary to apply non-Euclidean geometry to the study of the physics of cosmology. Thus relativity and cosmology can be studied even from the geometrical point of view.

Maxwell's equations for electromagnetic phenomena are true only for a fixed frame of reference. The form of these equations when

referred to a uniformly moving set of axes was first given by Lorentz. But Lorentz's form demanded a distortion in the space-time frame which appeared absurd on the basis of classical ideas. Lorentz and others contended that this distortion was due to the drag of the all-pervading ether on the moving frame and that the distorted space and time were not, therefore, real. The classical conception of the ether was, however, soon found to be unsatisfactory and relativity came forward which, while it retained the mathematical analysis supplied by Lorentz gave a strikingly new interpretation to the mathematical results. The details, we may for the present leave aside as our business now is only to indicate how a topic in electromagnetism leads to the theory of relativity.

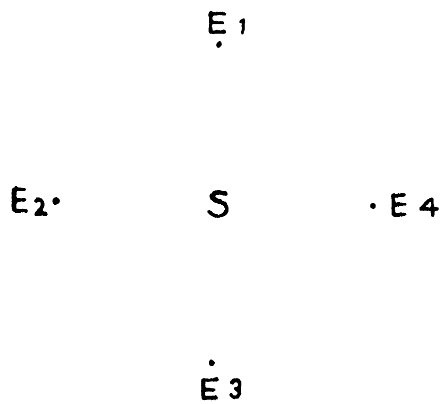
It becomes obvious from Einstein's earlier papers on the theory of relativity that a good deal of his inspiration came from the philosopher Mach.[2] The latter questions the very soundness of the ideas of space and time which Newton expresses in "The Principia". In his "*Principles of Mechanics*," published in 1893, Mach[3] argues that it is a very idle suggestion of Newton's that the time flows on uniformly. The flow can be uniform only with reference to something and hence the phrase, "uniformity of flow" has got no meaning in the absence of a standard. The conception of time probably arose out of a necessity. Our forefathers perhaps found it necessary to regulate their lives some way in which case it seems reasonable to suppose that the rising and setting of the sun provided them with a standard to mark off equal intervals. Thus the classical theory of space and time did not satisfy some of the searching philosophers of the pre-relativity days and a new theory such as the relativity theory was hunted for.

The modern conception of the universe is that it is a finite and unbounded hypersphere of radius 10^{27} cms., approximately. Yes! It is at once finite and unbounded in the same sense that a circle has a finite length but neither any beginning nor an end. The total mass in the universe is estimated at about 10^{22}, the mass of the sun being 1.99×10^{33} grs. Incidentally it becomes obvious that even as regards its mass the sun is a mere nobody in the galaxies of the universe, and the question arises as to how all the masses in the universe are distributed in space.

It has been estimated that there are over 10^{10} stars in the universe. All these stars, planets, nebulae, and other celestial bodies seem to possess each some relative motion with reference to the other bodies in the universe. There seems to be no body in the sky which is at absolute rest. The Greeks thought that the Earth is at rest and that all the other bodies in the space move about the earth. It was left to Kepler, as we have already remarked to pull this theory to pieces. It should however be observed that even if the geocentric theory of the universe was disproved by Kepler he had not yet proved that the

earth cannot be at absolute rest. The question was still open to enquiry and experiments were proposed from 1887 onwards to determine the absolute motion of the earth. It was quite in keeping with the philosophy of the time to imagine that some sort of a fixed medium, no matter how rare, extends over the whole space, in which all the material bodies are suspended. Such a medium may have fixed landmarks with reference to which they thought of measuring the velocity of the earth.

It is needless to go here into the series of experiments which are associated with the name of Michelson. Suffice it to say that the central question of the absolute motion of the earth slipped through the search of all experimenters. One important outcome of all the experimental investigations was that it was found out that the velocity of light cannot be compounded with the velocity of the source according to the parallelogram law. That this is so has been very ingeniously propounded by de Sitter from certain considerations of double stars. To make the argument simple we will treat the system of the sun and the earth as a double star. In the accompanying diagram S is the sun and E_1, E_2, E_3 and E_4 are four positions in the orbit of the earth such that the time to pass from any one position to the next is three months. According to the classical ideas if v is the velocity of the earth in the orbit and c the velocity of light, the latter will leave E_1 in the direction SE_4 with velocity $c-v$ and six months later light will leave E_3 in the direction SE_4 with velocity $c+v$. Thus the light from E_3 moves with a greater velocity than the light from E_1 and it is obvious that at some distance d an observer will receive the light from E_1 and E_3 simultaneously. An observer so situated will see the earth simultaneously in the two positions. From a simple calculation one can see that such an observer will have to be about 10^{16} kms., from the sun. Now about thirty to forty per cent. of the stars in any cluster are generally double stars and an occurrence as anticipated by de Sitter should be a matter of common observation. But as this phenomenon has not been observed one expects that the classical law of the composition of velocities fails when one of the velocities concerned is that of light.



Einstein gave quite a sensational interpretation to the failure of all experimental investigations to determine the absolute motion of the

earth. It is that it is not possible to determine the absolute motion by any optical instrument and that the velocity of light is always the same whatever be the motion of the source. The whole structure of the theory of relativity is based on this interpretation and any evidence to the contrary would be enough to destroy the relativistic philosophy. It will perhaps be of some interest to remark that Einstein's interpretation was subject to much criticism when first made and Prof. Miller[4] of America, one of his early critics still persists in his opposition. We find, however, hardly any sound justification for this opposition in Miller's investigations.

Einstein, therefore, enunciated as a law of nature that the velocity of light is a constant c, the same for all observers moving in any manner. A recent estimate gives c equal to $2{\cdot}99794 \times 10^{10}$cms., sec^{-1}. The question that now presents itself is whether any physical bodies in the universe can attain velocity greater than that of light. According to relativity a velocity greater than c, cannot be associated with matter or energy in any form as such velocities do not come within the range of experience. Many would challenge this statement as experiments could easily be suggested where a velocity greater than c should be discernible according to the classical ideas. Consider for example an experiment suggested by Eddington. If a powerful search-light, thrown from the earth, is made to rotate about eleven times a second in the plane of the orbit of Neptune then the observers at Neptune should find that the velocity of the beam as it passes across Neptune is greater than that of light. The solution which the relativist suggests to this difficulty is that the prediction of the observers of the earth as to what will be observed on Neptune is, based on the Newtonian conception of space and time. But the relativistic four-fold of space-time is warped, the time-scale near the earth is not the same as the time-scale near Neptune and it could be possible that the observers of Neptune will find the beam moving with a velocity less than c. That this is not only possible but is invariably so will be understood when an insight into the general theory of relativity is gained.

The Special Theory of Relativity.

Although it is true that we are concerned only with the space and time intervals between two events, frames of co-ordinate axes facilitate the work of ordering the experiences. A rectangular cartesian frame $(xyzt)$ is said to be Galilean when Newton's first law holds good in that frame. Now this law states that "every body perseveres in its state of rest or uniform motion in a straight line, except in so far as it is compelled to change that state by impressed forces". Hence if a frame K is Galilean another rectangular frame $(x' \; y' \; z' \; t')$ which moves away from or towards K with a uniform speed in the same straight line

is also Galilean. Let us call this other Galilean frame K^1. As we have already remarked it has not been possible yet to detect the absolute motion of any body in space. Hence there is no standard Galilean frame K with reference to which only the laws of Nature need be true. In other words the laws of Nature should hold good with reference to both K and K^1, the latter being any two Galilean frames. In essence this is the principle of the special theory of relativity.

Following Einstein one expects that the velocity of light is the same whether the observer is at K or K^1. The Galilean transformation connecting K and K^1 is $x' = x - ut'$, $y' = y$, $z' = z$, $t' = t$ when K^1 moves with a uniform velocity u, along ox, and away from K. Hence if a light signal is sent along the x-axis in K the velocity of light in the latter frame would be c while it would be $c-u$ in the other. Evidently the Galilean transformation is not consistent with the restricted principle of relativity, and a new transformation must be devised to meet the requirements.

The Lorentz transformation was found to fit in satisfactorily with the special theory. It runs as $x' = B(x-ut)$, $y' = y$,

$z' = z$, $t' = B(t - \frac{ux}{t^2})$ where $B = (1 - \frac{u^2}{t^2})^{\frac{1}{2}}$— This gives

$$dx'/dt = \frac{dx/dt - u}{1 - u\ dx/dt\ c}\ 2$$

so that when $\frac{dx}{dt} = c$, $\frac{dx'}{dt'}$ is also is c, and conversely.

According to Lorentz who discovered the transformation in connection with electro-dynamics (x', y', z', t') are not real if the other co-ordinates are. On the other hand, as there is no standard by which K can be judged to be superior to K^1 Einstein puts both the frames on equal footing. This would mean drastic changes in our habits of thought about space and time.

Einstein has also deduced the Lorentz transformation from a certain set of plausible assumptions. He does this in three steps. At the very outset he assumes that the required transformation between (x, y, z, t) and $(x', y', z', t',)$ must be linear and the cause of the linearity according to him is the homogeneity of space and time. This argument has appeared obscure to some and attempts have been made to obtain the linearity from first principles.[5] Once the linearity is accepted Einstein next applies in succession the principles of the relativity of the rod and the clock and deduces the Lorentz transformation. The principle of the relativity of the rod is something of the following sort. A and B are two neighbours so that naturally, either discounts the other's story. A has a cow which, he says, gives eight seers of milk per day, and B thinks that the cow must be giving only four seers in place of eight. Suppose by some chance the cow becomes

the property of B. Then if B tells that the cow gives ten seers a day, A is bound to think according to the analogue of the principle in question, that the cow really gives five seers of milk in place of ten. Thus the principle of the relativity of the rod says that if a metre rod in the frame K appears to be one-tenth less in the frame K^1 then a similar impression will be received in K if a metre rod is placed in the frame K^1. To understand the principle of the relativity of the clock it is necessary to know first what is meant by a clock. The function of a clock is to give equal intervals of time. Hence to get a clock ready we have only to procure a metre rod and define as a unit interval the time taken by light to traverse the distance. From the standpoint of a common observer the metre rods in K and K^1 differ while the velocity of light is the same. Hence the standard clocks in K and K^1 also differ. As the principle of the relativity of the rod has already been used all that the principle of the relativity of the clock amounts to is that the velocity of light is the same in both K and K^1. This is the third step in Einstein's deduction of the Lorentz transformation.

The obvious interconnection between space and time in the Lorentz transformation gives rise to quite a new philosophy. Let us consider two observers K and K^1 carrying each his own Galilean frame. Suppose that the two are together at $t = O$ when a light signal is sent. After a time t it will lie somewhere on a sphere with centre o and radius ct, where c is the velocity of light. Let in the meantime K^1, who has a uniform velocity u along ox arrive at O' so that $OO' = ut$. Draw $O'P$ perpendicular to OO' so as to meet the sphere somewhere in P. Let us suppose that the signal was originally sent in the direction OP. Let the time of reaching at P be t' according to O'. Of course t cannot be equal to t' as the measures of time of K and K^1 differ. Hence $O'P = ct'$. The distance $O'P$ being perpendicular to the direction of relative motion will be the same according to the estimates of K as well as K^1.

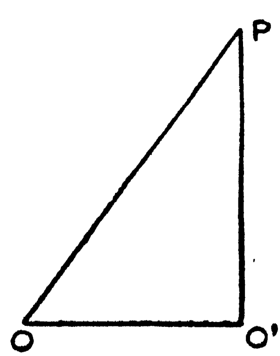


FIG. 2

Considering O, O′, P as three points in the frame K, we get

$$c^2t^2 = \quad u^2t^2 + c^2t'^2$$

$$t' = t(1 - \frac{u^2}{c^2})^{1/2}$$

Also the distance OO′ is l or ut when measured by K, while the same distance is l' or ut' when measured by K¹. Thus

$$\frac{l}{l'} = \frac{t}{t'} = (1 - \frac{u^2}{c^2})^{1/2}$$

We have seen here that the same distance OO′ is measured as l by one observer and as l' by another. Similarly the same duration of time is measured by one as t and by the other as t'. There is no reason why the measure l or l' should be preferred to the other and hence the concept of absolute length becomes futile when it comes to the measurement of it. In the same manner the clocks of K and K¹ may be synchronized at any chosen moment but as the same duration is given by different measures on the two clocks the events that are simultaneous to K are not so for K¹ after $t=0$, hence the concept also of the absolute simultaneity fails.

The effect on the moving rod is sometimes called the Fitzgerald or the Lorentz contraction and the slowing up of time in the moving frame, the Einstein dilatation. These effects may be deduced straight-away from the Lorentz transformation itself. Take two points x_1 and x_2 in the frame K corresponding to points x'_1, x'_2 in K¹ at a certain instant t. Then

$$x'_1 - x'_2 = \text{B}(x_1 - x_2)$$

As B> the observer in K will say that the observer in K¹ will find on measurement the distance, $x_1 - x_2$, B times greater. From this K will deduce that the rod in K¹ is B^{-1} times as short as the measuring rod in K. This contraction of the rod K attributes to the motion of K¹. Similarly, choose two time-epochs t_1 and t_2 at any point x. Then from the transformation, if t'_1 and t'_2 are the corresponding instants,

$$t'_1 - t'_2 = \text{B}\ (t_1 - t_2)$$

K finds that according to the clock of K¹ the duration $t_1 - t_2$ is B times greater. In other words K¹ thinks that in the moving frame K the clock runs slow.

Although neither the space-interval nor the duration of time is invariant for Galilean transformations there is a new entity S which remains invariant. This is defined by

$$\text{S}^2 = c^2(t_2 - t_1)^2 - (x_2 - x_1)^2 - (y_2 - y_1)^2 - (z_2 - z_1)^2 \text{ and hence}$$

also $\quad = c^2(t'_2 - t'_1)^2 - (x'_2 - x'_1)^2 - (y'_2 - y'_1)^2 - (z'_2 - z'_1)^2$

It is clear from this that space and time, considered individually reduce to secondary importance in relativity. S is called the "interval"

between two events *viz.*, x_1, y_1, z_1, t_1 and x_2, y_2, z_2, t_2.[4] The interval may be broken by different observers into different sections of space and time. This does not however mean that space and time are really on the same footing in the theory of Relativity. Only one is complimentary to the other. For if we look at the very form of S^2 the coefficient of $(t_2-t_1)^2$ is positive while that of $(x_2-x_1)^2$ is negative. Moreover in the very deduction of the Lorentz transformation Einstein makes use of two independent principles, one, that of the relativity of the rod and the other, that of the relativity of the clock. The rod and the clock are the two ultimate unanalysable concepts of the theory of relativity. It is, therefore, utterly wrong to say that relativity has removed the distinction between space and time.

All this new philosophy arose, as we have seen, because the absolute motion of the earth in ether has defied all experiments made to determine it. Now not only the absolute motion of translation cannot be determined but the absolute motion of rotation also is beyond the means of experiment. It has often been suggested that this latter motion should become manifest through the centrifugal forces that evolve with it. Newton, himself, was of the opinion that the absolute motion of rotation of the earth can be determined from a knowledge of the centrifugal forces. Mach objects to it on grounds that the centrifugal forces can arise also in a relative motion of rotation; that if the earth is supposed to be at rest and the framework of stars be supposed to be rotating there would be no data from our sense perceptions to distinguish this view from the current one and that the centrifugal forces might therefore arise, very naturally, also in this case. The story of an interesting experiment hangs here. Newton[6] proposed the rotating bucket experiment to demonstrate the existence of absolute rotation. A bucket about half full of water, was kept hanging vertically by a twisted wire. As the twist was released the bucket began to rotate. The water was first horizontal, but gradually the bucket imparted a motion to it till at last the bucket was stationary, and the water rotating, so as to rise from the middle to the sides of the vessel. Initially when the bucket was rotating and the water stationary there was no rise of water and Newton advances this in support of his argument that centrifugal forces do not arise in a relative motion of rotation. There is a very subtle and serious flaw in Newton's argument which Mach points out. The relative motion is not really the same in the two cases considered by Newton. In one case the water rotates not only relative to the sides of the vessel but to the fixed stars as well, while in the other only the vessel and not the stars are rotating relative to the still water.

This brings us directly to the idea of fields of force to be

associated with matter in motion generally. In the natural philosophy of Newton, space and time were something like definite markings on a large handkerchief. Suppose for a moment that all the objects of the universe lie on one such handkerchief of a four-dimensional extent. The masses and motions of these objects are studied under the influence of forces with the help of the space-time markings. On the other hand, in the new philosophy the four ends of the handkerchief are tied together by the law of the velocity of light. The objects inside disappear from our view and creases on the cloth come into view. The creases alter as the bodies move inside. Each body has its own field of force which is revealed by the creases on the handkerchief. The general theory of relativity is concerned with the study of the curvatures in space and time introduced by matter and motion.

The concept of a curved space-time is strictly foreign to the reader of relativity. Its implications are deeply rooted into the subject and we shall discuss them briefly later on. We will content ourselves for the present merely with indicating how relativity has changed the philosophy of mass. In relativity fields of gravitation can be intense enough to defy exploration. It is not, for example, possible to explore a centrally condensed mass. Suppose we have a large pole going out of such a mass and a monkey runs down it with a rod and a clock then he will never reach the centre of the mass. As to why this should be so we will learn from the general theory of relativity.

In the general theory of relativity we do not confine ourselves to the Galilean frames only. The Lorentz transformation ceases, therefore to fill the theatre of action from now on, new objects called tensors come into view.

To understand the tensors consider first the restricted principle of relativity, which says that all laws of Nature are covariant with respect to the Galilean frames. In the general theory we want equations to indicate the covariance of the laws with respect to all possible co-ordinate systems. A tensor, equated to zero, furnishes an equation of this type which accounts for the importance of the tensors in the general theory. It is very important to know which relations are good for all the co-ordinate systems and which are valid only for a certain co-ordinate system. Suppose we look at a man sitting on a table through a number of convex lenses, using one at each time. One of the impressions that will ever persist while these observations are being carried out is that a man is sitting on the table. But we would have different impressions about the sizes and inclinations of the legs of the table or of the face of the man. That the legs of the table are uniform may be an impression when

there is no convex lens but that certainly does not always remain the impression; and hence this is not anything like a tensor relation while the other observation, *viz.*, that the man and the table are together is of the tensorial character.

A tensor equation looks something like the following :—

$$A^{i_1 \quad i_2 \ldots\ldots\ldots i_p}_{j_1 \quad j_2 \ldots\ldots\ldots j_q} = 0$$

The symbol on the left hand side is called a tensor of the order r where $r = p + q$, it is further said to be contravariant in p suffixes and covariant in q suffixes. The above equation really stands for n^r equations where the r suffixes $i_1, i_2, \ldots\ldots\ldots j_q$ can each take up any of the values 1, 2, 3. .... to n. Analytically two tensors are alike when they have the same suffixes at the top and the same suffixes at the bottom, in both the places the order of the suffixes also being preserved. When there is no suffix attached to a symbol the latter is called a scalar. A single suffix gives a vector, contravariant or covariant according as the suffix is at the top or at the bottom. Essentially there is no distinction between a covariant and a contravariant vector. If a matrix A transforms a covariant vector into another the matrix $(A^1)^{-1}$ transforms a contravariant vector into another. But if we call $B = (A^1)^{-1}$, $(B^1)^{-1} = A$. The dash is used here to indicate that the rows and columns are interchanged. Analytically there are two types of vectors, those which are transformed by the matrix A and those which are transformed by the matrix B. Either type may be called covariant the other type being then considered to be contravariant.

In the general theory, an infinitesimal interval ds is defined by

$$ds^2 = \sum^4_{\Upsilon=1} \sum^4_{\mu=1} g^{\mu\Upsilon} \, dx^{\mu} \, dx^{\Upsilon}$$

$g_{\mu\Upsilon}$ is the fundamental tensor of Relativity. Davidson and Germar[7] considered a number of tensors generated by $g_{\mu\Upsilon}$. The gravitational equations of Relativity are

$$G_{\mu\Upsilon} - \lambda g_{\mu\Upsilon} = -K\left(T_{\mu\Upsilon} - \tfrac{1}{2} T g_{\mu\Upsilon}\right).$$

Where $G_{\mu\Upsilon}$ is the contracted Riemann-Christoppal tensor, $T_{\mu\Upsilon}$ the energy tensor, K stands for $\frac{8\pi G}{c^2}2$, where G is the gravitational constant. The term λ is the cosmological term. It was Einstein who proposed first this small correction to his relativity equations to get a finite spherical universe. Later, in his exposition, Eddington has attached some philosophical significance to this step, which, however, has not been widely accepted. It was only last year that Einstein

proposed to do away altogether with λ. Eddington and a large number of other relativists are not prepared to take this step. We shall come to this topic again later on.[8]

The units that are commonly used in relativity are called natural units and might prove to be of some interest here. In the natural units the gravitational constant G and the velocity of light c are both unity, and the unit of time is the second. The unit of length therefore is $3 \cdot 10^{10}$ cms., and the unit of mass is given by $G = M^{-1}L^3T^{-2}$ *i. e.*, $6{\cdot}65 \times 10^{-8} = M^{-1}\,(3{\cdot}10)^3.\,(1)^{-2}$ or $M = 4{\cdot}06 \times 10^{38}$ gms., which is the unit of mass. This is rather a large unit for the mass of the sun turns out to be only $\frac{2{\cdot}70^{33}}{4{\cdot}06} \times 10^{38}$ *i. e.*, $\frac{1}{2}{\cdot}10^{-5}$ units approximately. Now comes a very interesting point. Mass in relativity is recognized, usually, either from its inertial aspect in which case $m = \frac{1}{2}{\cdot}10^{-5}$ units or as a region of singularity of a certain radius. In the latter case, of course, it is convenient to express mass in units of length. Now a unit of length here is $3 \cdot 10^{10}$ cms., and, therefore, the mass of the sun might be expressed as 1·5 kms.

Let us now consider the question of the interaction between mass and space. The Schwarzschild solution for a particle of mass m is of the form

$$ds^2 = -\left(1 - \frac{2m}{r}\right)^{-1} dr^2 - r^2\,(d\theta^2 + \sin^2\theta\, d\theta^2) + \left(1 - \frac{2m}{r}\right) dt^2$$

It is obvious that the 'radius' of the sun as defined above is 3 kms. It becomes clear even from the study of the internal field of a body of spherical symmetry that

$$2m < a$$

where a is the radius of the sphere. Let ρ be the average density of the mass. Then $\rho < \frac{3}{8\pi}\, a^{-2}$.

Given the average density of a sphere there is thus a limit on the radius of the sphere. Thus when the average density is that of water it can be shown that the radius of the sphere cannot exceed about 400 million kilometres. We should remark here that the limit on the radius given here is applicable to all spheres with a radical distribution, the case considered by Schwarzschild being only a particular case viz., that of a homogeneous sphere.

Why should there be a limit at all in relativity on the radius of a material sphere? The reason is this: matter by its very presence makes the space about it curved so that as matter begins to be packed about a point the space about it gradually curves so that ultimately no more matter can be introduced inside.

Emdern's equation for a polytropic gas sphere of degree n is of the form

$$x^2\theta^n + \frac{d}{dx}\left(x^2\frac{d\theta}{dx}\right) = 0$$

Where x is the "reduced" radius and θ the "reduced" temperature. We have worked out purely out of mathematical interest the relativistic analogue of this equation which is

$$x^2\theta^n + \frac{d}{dx}\left|\frac{x^2\frac{d\theta}{dx} + Ax^3\,(\theta^{n+2}+\theta^{n+1}+)}{1+A\theta-2\,(n+1)\;Ax\,\frac{d\theta}{dx}}\right| = 0$$

Here $A = \frac{p}{\rho\theta}$, p being the pressure and ρ the density, both expressed in natural units. x is such that at the surface of the sphere $x = 1$. In Milne's theory of the stellar structure the question of a centrally condensed sphere comes to the front. In a model of this type the condensation at the centre may be great enough to make the application of the relativistic correction necessary. It is with this end in view that we first attempted to obtain the above analogue.

Another question that we have found of some interest to discuss is whether space can hold condensed radiation under its own gravitation. The mathematical formulation that we have made of this question is as follows : is it possible to have a distribution of matter for $r \leqslant a$ such that $\rho = \rho\ (r) = 3p$ where ρ is the density and p the pressure.[2] The result of our investigation is that radiation cannot condense in this manner.

There are several properties of the distribution of matter which satisfies a line-element of the form

$$ds^2 = +\, g_{11}\, dx_1^{\,2} \times g_{22}\, dx_2^{\,2} \times g_3^{\,2}\, dx^{22} \times g_{44}\, dx_4^{\,2}$$

where g_{11}, g_{22}, g_{33}, and g_{44} may be all functions of x_1, x_2, x_3 and x_4. We shall go into all of them, but mention here one which we have found to be of special interest. It is that at each point of the three dimensional space $p\ (dv)\ \frac{4}{3}$ is a function only of x_1, x_2, and x_3 where p is the pressure and dv the elemental volume at the point in question. We may call this the adiabetic law for the expansion of space as in deriving it we have used the property that the proper mass of the element dv remains unchanged in time.

We come now from the interior of a material body to its exterior.

Let us consider now the external field of a point mass.[9] The empirical value of π, determined in the sun's gravitational field, is certainly different from the value of π known in pure mathematics. The radial distance from $r = r_0$ to $r = r_1$

is $d = \int_{r_0}^{r_1} \frac{dr}{1 - \frac{2m}{r}} = \left[\sqrt{r\,(r-2m)} + 2m \log\left(\sqrt{r-2m} + \sqrt{r}\right)\right]_{r_0}^{r_1}$

We shall take $r_0 > 2m$. If $\frac{m}{r_0}$ is very small

$$d = r_1 - r_0 + m \log \frac{r_1}{r_0} \text{ approximately.}$$

The empirical value of π, say π^1, will be given by $\pi^1 = \pi \frac{r_1 - r_0}{d}$

$$\text{Hence } \frac{\pi - \pi'}{\pi} = \frac{m}{r_1} \log \frac{r_1}{m}, \text{ if } r_0 = 0\,(m)$$

If we take for m the mass of the sun and for r_1 the average distance of the earth from the sun we find that π^1 differs from π in the sixth decimal place.

We will wind up with considerations respecting the bending of light which at once attracted the public attention and proved a genuine test of the theory of relativity. We know that a particle having a finite velocity at infinity describes a hyperbola under the gravitational attraction of another mass. If we take a corpuscle of light moving with velocity c its path under the action of the sun would be a hyperbola; the velocity is, of course, supposed to be c not everywhere but only at the perihelion. The angle between the two asymptotes gives the deflection of the path of light and is found to be $\frac{2m}{R}$, when small where m is the mass of the sun and R the distance from the sun at the perihelion. From relativistic considerations we get for our deflection $\frac{4m}{R}$ in the same problem. In relativity the deflection is obtained by considering the field of the sun. The geodesies of the field are assumed to be the possible paths of lights as well as of small particles. The particle problem is this. We consider a star occulted by the sun. If the light really bends round the sun as theory predicts it should be possible to photograph the star even when it is occulted. But such a photograph could be taken only at a total eclipse of the sun for under other circumstances the stellar image would be lost sight of on the photographic plate. In order, therefore, to calculate the bend of light it is necessary to predict from where and when a total eclipse of the sun would be visible. To add to this a known star must then be occulted by the sun. Only when all this is done and the weather conditions and the local conditions are favourable the necessary experiment can be started.

Freundlich[10] has suggested that the relativistic effect on light is not large enough to account for the observed result. It has been suggested in this connection that the gravitational equations of relativity have not yet attained to their final form and that, perhaps, they could be so re-written as to remove this difficulty. I understand that the

solar eclipse for which expeditions were sent to America last July was not favourable for making any new test on the bend of light.

A certain interesting aspect of the mathematician's mind has been brought to light in a recent book, "*The World of Science*" by a mathematician of repute, Prof. H. Levy. It was said by one of those cynics whom one meets on the London embankment that Sir James Jeans is the Pope and "*The Mysterious Universe*" the Bible of modern science. The same cynic might have called Prof. H. Levy a Martin Luther. For the latter challenges the significance of one of the most easily accepted criteria of scientific advance. This criterion is what is called the simplicity criterion according to which the simplest law is chosen when alternative laws can be found to fit facts. Prof. Levy argues that the criterion is meaningless as "simplicity" itself is not mathematically defined. What is simple from one point of view may not at all be so from another. Suppose we want to find out the simplest mathematical law connecting x and y which would be in conformity with the following five pairs of values:

$$\begin{array}{lllll} x=1 & x=4 & x=9 & x=16 & x=25 \\ y=2 & y=4 & y=6 & y=8 & y=10 \end{array}$$

One might consider (vide H. Jeffreys "*The Scientific Inference*") the simplest law in agreement with facts to be $y^2 = 4x$. But an alternative law according to which $y = 0$ for all values of x except the five may be called with equal justification the simplest law.

I do not think the question of simplicity deserves to be treated in cold blood like this. It really arises on the frontier of science where the leading scientists are continually engaged in a guerilla warfare. All the mathematical laws which fit in with known facts are in the field so long as they help further inferences and predictions. Only that law which is most fruitful in predictions ultimately survives the rest. The surviving law is more easily assimilated than the alternative, less successful laws and is naturally treated as the simplest. Thus the simplicity of the law may be due not to anything intrinsic but to our getting more familiar with it.

A position arises in relativity where the need of the simplicity criterion is felt. There are three invariants $K = G$ $K^1 = G_{\mu\nu} G_{\mu\nu}$ and $K'' = B^{\rho}_{\mu\nu\sigma} B^{\mu\Upsilon\sigma}_{\rho}$ whose covariant derivatives with respect to $g_{\mu\nu}$ furnish when equated to zero three alternative laws which are consistent with the laws of the conservation of energy and momentum. The law corresponding to K has been now in the field. The reason for choosing this particular law in preference to the other laws is that it has been most successful in its applications. One is also led to believe that this most successful law is the simplest of the three to work with.

Of the new principles that the theory of relativity has brought in its train those of equivalence and identification deserve a place here. The principle of identification has to be very frequently used in special problems of relativity. The idea behind it may be very easily explained. A vital equation of a problem which should be tensor equation cannot often be put down for want of knowledge of the necessary tensor. But it is possible sometimes to formulate the equation in a certain set of co-ordinates. Suppose then that we hit upon a tensor whose components in the chosen co-ordinate system are the same that we have used then we look upon this tensor as the required tensor by the principle of identification. This principle has been used in equating the components of an energy tensor with multiples of those of the contracted Riemann-Christoffel tensor. The general gravitational equations of relativity were first written down in the cartesian co-ordinates and were taken over to the tensorial form by the use of the principle of identification.

The principle of equivalence is, comparatively, of greater importance, in the formal development of the theory. According to this principle some of the differential equations which are true for a flat space-time are also taken to be true for a curved one. There is no *a priori* reason for doing so in a particular case. The method followed here is simply to try and see. When the method is successful appeal is made to the principle in question; when it fails it is not the principle that is blamed but the equation under consideration!

Talking generally, in applying both the principles mentioned above the procedure adopted is the same. Starting from certain assumptions we deduce first their logical consequences to some length. Then we try to proceed backwards by inference from certain data which are either empirical or which still hold the field because of their success. The processes of deduction and induction are thus welded together at some point where an appeal is made to one of the two above principles.

We shall now try to present one or two problems in the theory of relativity that have occurred to us. We propose to consider two kinds of static solutions of Einstein's field equations for gravitational phenomena: firstly, those which give the field inside and in the neighbourhood of a condensation, and secondly, those which give static universes. Our own universe is now considered to be expanding but as the cause of the expansion from an initial state, static and unstable, is not yet fully explored it may be worthwhile to discuss different static states that are mathematically and physically possible. However some considerations will be first presented about the solutions of the field-equations in general.

The form of the line-element that comes very frequently in cosmological discussions is

$$ds^2 = -\theta^2_1 dx^2_1 - \theta^2_2 dx^2_2 - \theta^2_3 dx^2_3 + \theta^2_4 dx^2_4$$

where each θ is a function of x_1, x_2, x_3, and x_4. If we put $\theta_1 dx_1 = dX_1$, $\theta_2 dX_2 = dX_2$ etc., X_1, X_2, X_3, and X_4 become, in general, quasi-coordinates. If only the principal components of the energy-tensor exist the relativity equations reduce to the following;

$$-\frac{\Delta^2_1\theta_1}{\theta_1} - \frac{1}{\theta_2}\frac{d^2\theta_2}{dX^2_1} - \frac{1}{\theta_3}\frac{d^2\theta_3}{dX^2_1} - \frac{1}{\theta_4}\frac{d^2\theta_4}{dX^2_1} = \lambda - 8\pi\ (T^1_1 - \tfrac{1}{2}T)$$

$$-\frac{\Delta^2_2\theta_2}{\theta_2} - \frac{1}{\theta_1}\frac{d^2\theta_1}{dX^2_2} - \frac{1}{\theta_3}\frac{d^2\theta_3}{dX^2_2} - \frac{1}{\theta_4}\frac{d^2\theta_4}{dX^2_2} = \lambda - 8\pi\ (T^2_2 - \tfrac{1}{2}T)$$

$$-\frac{\Delta^2_3\theta_3}{\theta_3} - \frac{1}{\theta_1}\frac{d^2\theta_1}{dX^2_3} - \frac{1}{\theta_2}\frac{d^2\theta_2}{dX^2_3} - \frac{1}{\theta_4}\frac{d^2\theta_4}{dX^2_3} = \lambda - 8\pi\ (T^3_3 - \tfrac{1}{2}T)$$

$$-\frac{\Delta^2_4\theta_4}{\theta_4} + \frac{1}{\theta_1}\frac{d^2\theta_1}{dX^2_4} + \frac{1}{\theta_2}\frac{d^2\theta_2}{dX^2_4} + \frac{1}{\theta_3}\frac{d^2\theta_3}{dX^2_4} = \lambda - 8\pi\ (T^4_4 - \tfrac{1}{2}T)$$

Besides these there are the six equations.

$$\frac{\Delta_{14}\,\theta_2}{\theta_2} - \frac{\Delta_{14}\,\theta_3}{\theta_3} = 0, \quad \frac{\Delta_{23}\,\theta_1}{\theta_1} - \frac{\Delta_{23}\,\theta_4}{\theta_4} = 0, \text{ etc., etc.,}$$

In the above Δ^2_1 stands for the Laplacian operator for

$\theta^2_2 dx^2_2 + \theta^2_3 dx^2_3 - \theta^2_4 dx^2_4$; similarly for Δ^2_2, Δ^2_3 and Δ^2_4

As regards the six operators of the type Δ_{14} we have

$$\Delta_{14} \equiv \frac{d^2}{dx_1\, dx_4} - \frac{d \log \theta_1}{dx_4}\frac{d}{dx_1} - \frac{d \log \theta_4}{dx_1}\frac{d}{dx_4}$$

This type of operation is also associated with the name of Laplace and the operator is known as the Laplacian operator of the second kind.

A most general discussion of the above ten equations would be beyond our scope. But we can suggest a way for obtaining new particular solutions. For this split up the last six equations into the following twelve :

$$\Delta_{12}\,\theta_3 = \Delta_{12}\theta_4 = 0, \quad \Delta_{13}\theta_2 = \Delta_{13}\theta_4 = 0, \text{ etc.}$$

We have obtained some particular solutions by solving these sixteen equations which we hope to publish in detail elsewhere. Here we shall merely content ourselves with the remark that some of the most well-known solutions belong to our group, *viz.*, Lemaître's solutions and Schwarzychild's for a particle

We do not think that the general field of a nebula has been worked out, even to the first approximation in any of the standard text-books or memoirs on relativity. The result of our examination yields the following line-element :

$$ds^2 = -\left(1-\frac{4\pi}{3}\rho r - \frac{1}{6}\lambda r - \Phi\right)(dx^2+dy^2+dz^2)$$
$$+\left(1+\frac{4\pi}{3}\rho r^2 \frac{1}{3}\lambda r^2+4\pi p r^2+\Phi\right)dt^2$$

Here Φ stands for $\frac{2m_1}{r_1}+\frac{2m_2}{r_2}$ . . . . $\frac{2m}{r_n}$ where $m_1, m_2, m_3,$ . . . . m_n are supposed to be n masses whose distances from the current point are r_1, r_2, ... r_n respectively. Also the solution gives that p may be a function of time in which case p is such that $\rho - 3p$ remains constant.

The working out of this problem up to the second order is beset with almost insurmountable mathematical difficulties. The relativistic analogue of the problem of two bodies has not yet been solved. It is perhaps worthwhile looking into the problem of two fixed point-masses. We find that the line element to be taken for the exploration of the field is in dipolar co-ordinates of the form

$$ds^2 = -A \operatorname{Coscec}^2\Phi\,(dr_1^2+dr_2^2)+2\,B\cot\Phi\, dr_1 dr_2$$
$$-\frac{1}{4a^2}\, r_1^2 r_2^2 \sin^2\Phi\, d\Phi^2+c^2dt^2$$

where $r_1\,r_2 \sin\Phi$ is twice the area of the triangle formed by current point and the fixed positions of the two masses; A, B, C are all functions of r_1 and r_2 to be determined by solving the relativity equations. The differential equations that arise in this investigation have not yet been completely solved.

RELATIVITY AND COSMOLOGY

II

Cosmology deals with the origin of the universe and cognate problems. Once it was all talk—mere speculations—but now, and particularly since the advent of the theory of relativity cosmology is being guided by mathematical thought. Even in relativistic cosmology the speculative element is quite conspicuous and from the nature of the subject it is difficult to believe that this element could ever be wiped out of the subject.

It was Einstein who started the study of the world from the relativistic point of view. The theory of relativity had already been found more successful than gravitation for the phenomena of the Solar system. It was therefore natural to extend this theory as Einstein did to a much larger system, *viz.*, the world as a whole. Such an extrapolation, it should be remembered, was also made by Newton and it met at the time with an amazing success.

Einstein presented in his earlier discussions two reasons for believing the world to be finite. His first reason was not acceptable to

many and it was supposed to be due to the influence that Mach exercised over him. Mach contended that the inertia of a body increases when the other bodies in the universe are brought nearer to it. Einstein showed that this could be true only in a finite universe.

The other argument was more convincing to mathematicians. If the celestial bodies were subject only to the gravitational influence then the mean velocities of the stars of a cluster would be, as it has been found out, much greater than what they actually are. This shows that there is an all-pervading field of force which diminishes the influence of gravitation. Now it is the property of a finite static world to have such a field. These considerations led Einstein to take for a model of the universe a finite and unbounded one as presented by one of his solutions of the relativity equations.

Let us now consider some of the questions that have been provoked by the phrase "a finite and unbounded universe". The universe can be at once finite and unbounded just as a circle can be said to be so because its length is finite while it has no beginning or end i.e., no boundaries. Similarly a sphere has a finite surface and is still unbounded. The Einstein universe is a hypersphere whose surface is three-dimensional. Mathematically the departure from the familiar sphere to the hypersphere is a mere matter of taking one more variable while mentally the hypersphere defies conception. It is only by those who cannot conceive of a hypersphere the question is asked as to what is outside the universe, if it is finite. This enquiry is generally due to the associated idea that a sphere can be perceived outside another. Well! This is so because the two spheres exist in a three-dimensional space that can be explored by our senses. Similarly a hypersphere may exist outside another but the two form part of a four-dimensional space which cannot be explored by the senses. Thus we can pass from our finite universe to another "outside" only if we can stretch our limbs in the fourth dimension. This fourth dimension is space and should not be confused with what usually stands for the time-dimension.

The Einstein universe is characterized by a homogeneous distribution of matter, absence of pressure, and a linear relation between the total mass and the radius of the universe, *viz.*;

$$\frac{MG}{c^2} = \frac{\pi}{4} R$$

Here M is the total mass; relative or proper, it is the same as there is no pressure. G is the gravitation constant, c the velocity of light and R the radius of the universe. The linearity of the relation between M and R first came as a surprise to many but it can be derived even from purely gravitational considerations. Let R be the radius of a sphere and M the total mass contained in it. If this sphere is a very close model of the universe there must be something at the

surface of the sphere to limit the extent of the universe. The boundary condition we can think of is that radiation follows along the surface of the sphere. If we take the centre of the sphere as the centre of gravity of all the masses and c for the velocity of radiation, we have by equating the accelerations at the boundary,

$$\frac{MG}{R}=\frac{c}{R} \quad \textit{or}\ M.G=c^2R$$

Another interesting interpretation of this relation is that it defines the gravitational constant in terms of the total mass and the size of the universe.

There were two serious objections to Einstein's theory: One was that Einstein's universe is devoid of motion and another that a condensation of matter cannot exist in the universe. The actual universe is full of both motion and condensations and hence the Einstein's could not be considered a successful model of the universe.

An alternative solution of Einstein's relativity equations gave De Sitter another model for the universe. This is called the De Sitter universe. It is isotrophic in space and time but devoid of matter. A powerful field of repulsion occupies the whole universe so that any particle introduced into it is repelled from the centre. Evidently as a model the De Sitter universe is as unsatisfactory as the other. But it is clear that the properties of the models are complimentary and the required model for the universe lies somewhere between these two extremes.

Before considering a series of solutions of Einstein's equations from Einstein's to De Sitter's let us note a property of the latter. The time-element for De Sitter's universe may be expressed in the form

$$ds^2=-R^2\ [dx^2+\sin^2x\ (d\theta^2+\sin^2\theta d\phi^2)]\ +\cos^2x\ dt^2$$

At $x=\frac{\pi}{2}$ the time comes to a standstill, and this plane, therefore gives what is called the horizon of the universe. The horizon was first interpreted by Weyl as the seat of matter in this universe but this view has found no support. All singularities and eccentricities associated with a space-time frame cannot be necessarily due to the presence of matter; some of these may be purely of a mathematical interest and they can be transformed away.

All the static spherical universes that have both matter and motion have a line-element of the following form:

$$ds^2=-R^2\ [dx^2+\sin^2x\ (d\theta^2+\sin^2\theta d\phi^2)]\ +\ (A-B\cos x)^2\ dt^2$$

where A and B are arbitrary constants. $B=0$, $A=\pm1$ give the Einstein universe while $A=0$, $B=\pm1$ gives the De Sitter universe,

The pressure p and the density ρ are distributed according to the following formulae :

$$8\pi p = \lambda - \frac{1}{R^2} + \frac{2 B \cos x}{R^2(A - B \cos x)}$$

$$8\pi \rho = -\lambda + \frac{3}{R^2}$$

$$\frac{\partial p}{\partial x} + (p+\rho)\frac{B \sin x}{A B \cos x} = 0$$

For those models for which $\left|\frac{A}{B}\right| > 1$ there is no horizon while for those for which $\left|\frac{A}{B}\right| \leqslant 1$ there is. The models of the latter group are obviously of no physical interest and of the former group only a few which have the pressure and density everywhere non-negative are of some interest. Even here the uniform distribution of matter on the one hand and the uneven distribution of pressure on the other make these few models extremely artificial; and although they are so we have mentioned them as they have not received any notice in the general literature on cosmology.

The solution which was first discovered (1923) by Friedmann and later independently rediscovered (1930) by H. P. Robertson and Lemaître gives the well-known theory of the expanding universe. It should be remembered that De Sitter's solution had one special advantage over Einstein's, *viz.*, that it admitted the recession of such distant objects as the spiral nebulae. A study of the geodesies in de Sitter's universe shows that bodies at a distance from the centre move with velocities proportional to their distances. Now the spiral nabulae are the most distant objects known to the astronomer. They are being studied spectroscopically for fifteen years. The reddening of the light coming from these nebulae has been attributed primarily to their recession. But the recession could not give any support to De Sitter's theory until it was observed that all the spiral nebulae are receding. On a careful examination some of the spiral nabulae turned out to be exceptions. Later on these exceptions were explained away by the motion of the Solar system as whole. Hubble and Humason who have been engaged on the problem of the spiral nebulae for the last ten years present a linear relation between the distances and velocities of the spiral nebulae. The observational data in support of the linearity are not yet as satisfactory as they should be. The theory of the expanding universe has come into prominence mostly because it is in agreement with the linear relation.

We cannot pass on to the theory of the expanding universe without referring to two vital objections to it. One is that the reddening of the light may be due to the photons losing their energy

in collision on their way to us from the distant nebulae. It seems that the reddening from this source is not strong enough to account for the observed shift. Another objection is due to a similar argument advanced by Macdonald that energy might be leaking from the photon at a very slow rate on its way from the nebulae. The leakage is conspicuous because of the long time taken by light in reaching the earth from the distant spiral nebulae. So far as we know this objection has not received any consideration from the physicists.

The line-element for a non-static universe may be stated as

$$ds^2 = -R^2 \left[dx^2 + \sin^2 x \times (d\theta^2 + \sin^2\theta d\Phi^2 \right] + dt^2$$

Where R is a function of time. The distribution of matter in the universe is subject to the equations, sometimes called Lemaître's equations, *viz.*,

$$\lambda + K\rho = \frac{3}{R^2} + \frac{3\dot{R}^2}{R^2}$$

$$2\lambda - K(\rho + 3p) = 6\frac{\ddot{R}}{R}$$

where $K = \frac{8\pi G}{C^2}$ in the usual notation and $\dot{R}$ means $\frac{dR}{dt}$ etc. We cannot know from the above two equations whether the universe is expanding or contracting or oscillating. The equations simply tell us that the radius R of the hypersphere under consideration is a certain function of time obeying certain restrictions. Two methods have been used to take the problem of evolution. One method is to supplement the relativity equations with an additional one representing a physical criterion. Another method is to put $\lambda = 0$. Let us first study the second method.

The constant λ was first introduced by Einstein for cosmological considerations only. It is so small that the modification introduced by λ in the relativity equations is negligible for all other considerations. Thus the modified relativity equations were

$$G_{ur} = \lambda g_{ur} = -K(T_{ur} - \tfrac{1}{2}Tg_{ur})$$

Only the equations so modified can give the finite and unbounded static universe of Einstein. We have already mentioned that Einstein was led by several reasons to think that the universe is finite. Hence it is clear why the modification was effected.

Eddington has advanced philosophical considerations to justify Einstein's modifications. He argues that the principle of the relativity of length must be introduced to make the theory of relativity logically complete. When we say that a certain rod is ten metres long we do so by comparing it with some standard rod usually placed at a different place. Such a comparison assumes that the standard rod when moved from place to place remains unaltered which is certainly without any

justification. We therefore want a standard for comparison at any place and that is furnished by the local radius of curvature which is determined by λ. λ has the dimensions L^{-2}. For the Einstein universe $\lambda = \frac{1}{R^2}$. The length of any vector Ar is $\sqrt{g_{ur} A A^r}$.

This is connected with the invariant $\sqrt{G_{ur} A^u A^r}$ by

$$G_{ur} A^u A^r = \lambda = G_{ur} A^u A^r.$$

in free space. Thus

$$\frac{\sqrt{g_{ur} A^u A^r}}{\frac{1}{\sqrt{\lambda}}} = \sqrt{G_{ur} A A^r}$$

or $\frac{\text{the local length}}{\text{the local radius of curvature}} =$ the local value of a certain invariant.

The importance of λ in this respect has not yet been recognised by several relativists. Einstein himself in 1931 put $\lambda = 0$ firstly because the non-static solution does not need λ and secondly because it has introduced a number of difficulties that have not yet been got over. Perhaps it was De Sitter who first suggested that λ is a constant too many in Lemaître's equations.

It is now necessary to tell why an expanding universe is preferred to the other non-static universes. If we imagine ourselves to be at the centre of an expanding bubble we observe a scattering and recession of the marks on the bubble. Our own universe may not be a perfect sphere. It is highly irregular at places and yet a hyperspherical universe serves as a model to our own. The surface of the hypersphere is three-dimensional and the planets, the stars, the nebulae etc., are landmarks on the spherial surface. Now the recession and scattering would be most conspicuous in the most distant objects. The proof of the expansion is therefore to be sought in the spiral nebulae. The spiral nebulae are observed to be receding according to the approximately linear relation between distance and velocity, *viz.*, 600 kms. per second per parsec. Eddington has been able to predict from the space-interaction term in the wave equation of an electron that the velocity of recession is 528 kms. per sec. per parsec. In view of the uncertainty of the astronomical data employed here the agreement between theory and observation may be said to be remarkably close.

Let us consider now Lemaître's equations for an expanding universe with $\lambda = 0$ as has been suggested. Then

$$k\rho = \frac{3}{R^2} + \frac{3\dot{R}^2}{R^2}$$

$$-k(\rho + 3p) = 6\frac{\ddot{R}}{R}$$

Since p must be ever non-negative and ρ always positive there cannot be a stationary state for which $\dot{R}=0$, $\ddot{R}=0$. Moreover as R is always negative the universe will expand to a certain maximum and then contract till the matter of the universe allows it to.

A serious objection to the above theory is that it gives no satisfactory answer to the fundamental question as to how the expansion arose or what the initial state of the universe was. It has therefore been found necessary by certain investigators to keep λ as it is and to supplement the relativity equations with a criterion to obtain a solution.

It is fair to state in the very beginning that no satisfactory criterion has been discovered so far. In his original paper Lemaître suggested that the conservation of the proper mass should be assumed with the cosmic pressure always negligible. In the real universe the proper mass is certainly not conserved as the celestial bodies (most of which are radiating) lose it in radiation; for radiation has no proper mass. That the relative mass is conserved is also an unsatisfactory hypothesis as it changes with motion. Lemaître did sketch out in his first paper the evolution from the Einstein state which is a stationary state of Lemaître universe. But his assumption that the pressure is negligible withstood all attempts to explain the origin of expansion in the Einstein universe.

Eddington has shown that the Einstein universe is unstable. According to him it is quite a reasonable hypothesis that the Einstein state was one of the initial states of the universe. In this model there is a homogeneous distribution of matter. In the universe as it is most of the matter has been condensed into stars and nebulae. The question that now strikes one is whether the expansion arose owing to the formation of condensations in the Einstein universe. There is one difficulty at the outset, that of the time-scale. It is estimated that the stars are about 10^{13} years old while the expansion is, comparatively quite a recent phenomenon as it could have arisen only 10^{10} years ago. De Sitter is serious about this difficulty while Eddington takes the view that once the problem of the expansion is solved reasons may be found out to bring the age-limit of the stars much nearer to 10^{10} years.

Confronted with the above question McVittie and McCrea started with building a mass condensation in the Einstein universe so as to see whether the volume of the universe thereby increases, the total proper mass being supposed to be conserved. They started with two different line-elements and obtained contrary results. There is nothing puzzling about them as it was doubtful whether the mathematical singularities considered by them were mass-points at all. Later on they discovered another mistake in their calculations and have now come to the conclusion that the second order terms will have to be

considered to know whether the increment in volume is positive or negative.

It seems to us that the real difficulty in the procedure is due to the mass-point being not well defined. The problem of a mass placed in the Einstein world must be first solved: the equations governing the field of the mass must be fully solved; and then only we can consider the effect of the formation of condensations on the Einstein universe. In a static universe the field outside an isotropic singularity is given by the line-element

$$ds^2 = -e^{\mu}\, dr^2 - r^2 (d\theta^2 + \sin^2\theta\, d\phi^2) + e^{\nu} dt^2$$

where μ, ν and p, ρ are governed by the following field-equations:

$$e^{-\mu} = 1 - \frac{2M}{r} - \frac{\lambda}{3}\left(r^2 - \frac{a^3}{r}\right)$$

$$e^{-\mu}\frac{\partial \nu}{\partial r} = kpr + \frac{2M}{r^2} - \frac{\lambda r}{3}\left(2 + \frac{a^3}{r^3}\right)$$

$$\frac{\partial p}{\partial r} = -\frac{1}{2}(p+\rho)\frac{\partial \nu}{\partial r}$$

$$\text{where } M = \frac{K}{2}\int_a^r \rho r^2\, dr + m$$

m and a being the mass and the radius of the condensation. One may at once anticipate that all singularities subject to these equations cannot be identified with mass-points whose properties are familiar; an assumption connecting the four variables p, ρ and μ, ν is necessary.

De Sitter who was the first to look into this question assumed ρ to be constant. His solution was only a first approximation. Silberstein, however, considers this for a higher approximation and shows that the apparent difficulties at the polar of a mass-point are real and they cannot be transformed away. Moreover, while ρ is constant p becomes a function of position which makes De Sitter's assumption extremely artificial. McVittie and McCrea make an assumption about ν. This is also very unsatisfactory as one doubts as to whether the singularity obtained by them is a mass-point at all. This is certainly a vital point in the determination of the effect of condensations on the volume of the three-dimensional space since mathematical singularities of different types may lead to different results.

A criterion is therefore necessary to distinguish a mass-point from the other, mathematically possible singularities that inevitably arise in the solution of Einstein's equations. This criterion to be furnished by the external field must be of a tensorial form. For it is then that any peculiarities of the external field which are not

desirable can be transformed away if at all. A suitable criterion is furnished by the world curvature G which is given by

$$G = KT + 4\lambda$$

We see at once from Schwarzschild's solution that a mass-point in empty space does not alter G. Extending this idea to the world full of matter and motion the criterion for a mass-point to be taken is that the world-curvature is not disturbed by it. This is the extra condition necessary to supplement the field equations to determine p,ρ and μ,ν.

The above criterion also furnishes the much needed extra condition to determine the evolution of the Lemaître universe. Consider an Einstein universe in which condensations are formed. Then everywhere except at these singular points the criterion furnishes an equation. As we have shown elsewhere this is enough to indicate that such condensations produce a tendency in the universe to expand.

We are giving in the end a number of references for those who want to pursue the subject further. It should however be remembered that no theory of cosmology can ever be complete as the observational data are ever so poor. One wonders as to what would be the theories three or four years from now when the new 200 inch telescope at Mt. Wilson becomes ready for observation!

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THE PART OF MATHEMATICS IN THE HISTORY OF THOUGHT

By

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The general impression of a fairly cultured man about mathematics is very vague if not blank. Probably he has a faint recollection that mathematics is concerned with elaborate formulae and bewildering constructions involving a copious use of symbols and diagrams entirely unintelligible to the majority of people. The essential features of mathematics remain unnoticed by a man of average education, still less can we expect him to understand the part it has played in the history of thought or the contribution it has made to the progress and civilization of mankind. I propose to discuss in this paper the profound influence mathematics has exercised on the thinking minds from the earliest times up till now.

It is held that Mathematical Science is the most original creation of the human spirit, though another claimant for the same honour is music. The originality of Mathematics consists in the fact that relations between things are exhibited in the Science of Mathematics which are extremely unobvious apart from the agency of human reason. On reflection we see that mathematical thought is all pervading and enters every department of mental activity. The grocer when he weighs his sugar makes use of mathematical conceptions; when he enters his receipts, he uses a notation developed by a mathematician. The engineer employs methods and concepts of mathematical thought when he is building a bridge. The philosopher reflects on space and time, on number and quantity, on matter and motion which as well belong to the regions of mathematical thought. Recent developments in the study of heredity and eugenics have been rendered possible by the powerful weapons of mathematics. The study of statistics depends on the use of graphs and mathematical calculations.

Let us stretch our imagination backwards through thousands of years and endeavour to realize the gradual development of mathematical ideas. Take the question of numbers. The number 'two' applies to appropriate groups of any entities whatsoever—to two eyes, two apples, two books, two days &c. Thus the numbers are independent of any 'aggregate' and 'aggregates' which are equivalent to one another are said to have the same number. If we compare the number 'five' to the number 'two' we are thinking of two groups of

things. It is a remarkable feat of abstraction to establish this relationship between two groups of entirely different objects. The man who discovered the analogy between a group of seven apples and one of seven days made a notable advance in the history of thought. He was the first man who established a concept belonging to the Science of Pure Mathematics.

Let us see what is the function of Pure Mathematics in thought. It is a resolute attempt to go the whole way in the direction of complete analysis so as to separate the elements of mere matter-of-fact from the purely abstract conditions which they exemplify. The characteristic of mathematics is that in it we have always got rid of the particular instance and even of any particular sorts of entities. No mathematical truths apply merely to fish or merely to stones or merely to colours. So long as we are dealing with pure mathematics, we are in the realm of complete and absolute abstractions. The reason insists that if any entities whatever have any relations which satisfy such and such purely abstract conditions, then they must have other relations which satisfy other purely abstract conditions.

The second characteristic is the certainty of mathematics which depends upon its complete abstract generality. Such an abstract generality cannot be arrived at without some presupposed conditions. These are called the axioms and postulates which have not a *priori* certainty without some definitions. The third characteristic of mathematical abstraction is that our abstract postulates hold for the particular case in question. To take an example from arithmetic: It is an abstract truth that any group of forty entities can be subdivided into two groups of twenty entities. So coming to a particular case, we conclude that a particular group of 40 apples can be subdivided into two groups of apples of which each contains twenty apples. But there remains the possibility that we have miscounted the big group and one of the two heaps, on subdivision has an apple more than the other. Thus there is great room for error in the process of verification for the particular case. The function of a mathematician, therefore, is not to see whether his definitions and postulates are accurate representations of things or not in our physical universe but to see that they are not self-contradictory and are mutually consistent. This is the essence of mathematical physics. When mathematical processes are applied to physics, an assumption is made that the definitions and postulates in the Science of matter are applicable to Physical phenomena. If this assumption is incorrect, the mathematical deductions disagree with experimental tests.

This love for abstract generalisation enlightens every act of the functioning of the human mind. It emphasises the direct æsthetic appreciation of human experience. Secondly there is the abstraction

of the particular entities involved, viewed, in themselves and as apart from that particular occasion of experience in which we are apprehending them. Lastly there is the further apprehension of the absolutely general conditions satisfied by the particular relations of those entities in that experience. They are conditions which might hold for an indefinite variety of other occasions involving other entities and other relations between them. These conditions are perfectly general because, they refer to no particular occasion, to no particular entities and to no particular relationship between such entities. The generality of mathematics is the most complete generality consistent with the community of occasions, which constitutes our metaphysical situation. Thus the idea of a 'variable' is introduced into mathematics and mathematical logic because, the general conditions transcend any one set of particular entities. It is by the introduction of this notion that the general conditions are investigated without any reference to the particular entities. The exercise of logical reason is always concerned with these absolutely general conditions. The harmony of the logical reason is the most general aesthetic property arising from the mere fact of concurrent existence in the unity of one occasion. Whenever there is a unity of occasion there is thereby established an aesthetic relationship between the general conditions involved in that occasion. This aesthetic relationship is that which is divided in the exercise of rationality. This reasonable harmony means that for things to be together involves that they are reasonably together.

Pythagoras who lived in the sixth century B. C. was the first man who had any grasp of the full sweep of this general principle. Though our knowledge of him is fragmentary we know some points which establish his greatness in the history of thought. He insisted on the importance of the utmost generality in reasoning. He divined the importance of number as an aid to the construction of any representation of the conditions involved in the order of nature. He studied Geometry and discovered a general proof of the remarkable theorem* about the right angled triangles. On the side of Philosophy, he has discussion which has agitated thinkers ever since. "What is the status of mathematical entities, such as numbers, for example, in the realm of things ?" The number " two " for example is in some sense exempt from the flux of time and the necessity of position in space. The same thing can be said of Geometrical notions.

Pythagoras is said to have taught that mathematical entities such as numbers and shapes, are the ultimate stuff out of which the real entities of our perceptual experience are constructed. As thus stated the idea seems to be crude and indeed silly. But undoubtedly he had

* The general theory as well as a general proof of it had been discovered in India long before Pythagoras discovered what is surmised to be his proof of it.

hit upon a philosophical notion of considerable importance—a notion which has moved the minds of men for centuries together. To-day when Einstein proclaims that physical facts such as gravitation are to be construed as exhibitions of local peculiarities of the properties of space and time, he is merely following the pure Pythagorean traditions. The philosophical speculations of Pythagoras reach us through the mind of Plato. The Platonic world of ideas is the refined form of the Pythagorean doctrine that the number lies at the base of the real world.

Let us examine the developments of Geometry. The subject was originated in the empirical observations of the Physical world. But it has assumed forms of ever increasing abstractions. At the time of Pythagoras it became a purely rational science and the further development of Geometry was no longer dependent on the empirical observation. In rational Geometry points, straight lines, circles etc., are dealt with not as physical objects but as abstractions from objects perceived by senses. These possess certain properties in perfection which we only approximately realise in the Physical world. For example the straight line in rational Geometry has the properties of linearity and straightness in absolute perfection, whereas these properties are only imperfectly realised in any physical object which we may take as affording an approximate idea of a straight line. The precise properties of these idealised objects are fixed by means of some scheme of definitions, axioms and postulates, the nature of which is, to a large extent but not wholly, determined by empirical observation of actual relations in the physical domain. The history of geometry is of general interest because, Geometry may be regarded as the type of rational science which every science may be expected to conform to, at the distant time when a schematic representation of the Phenomenon with which it deals, is set up.

Thus Plato and Pythagoras contributed a lot to the concepts of mathematical reasoning. Aristotle now threw emphasis on classification by his Logic. Classification is a half-way house between the immediate concreteness of the individual thing and the complete abstractness of mathematical notions. Classification is necessary but unless we can progress from classification to mathematics, our reasoning will not take us far. Thus the popularity of Aristotelian Logic retarded the advance of physical science throughout the middle ages. In the interval of nearly two thousand years between the time of Pythagoras and Plato to the 17th century, mathematics had made immense strides on technical lines but did not play much part as a formative element in the development of Philosophy. Some of the old ideas lingered on but philosophy received no fresh inspiration from the steady advance of mathematical science. In the 17th century the influence of Aristotle was at its lowest and mathematics received its

importance of the earlier period. It was an age of great philosophers and great physicists, and the physicists and philosophers were alike mathematicians. It was the age of Galileo, Descartes, Newton and Leibnitz. Mathematics was an influence of the most pronounced order in the formation of philosophic ideas. The mathematics that now came into prominence was a different science from the mathematics of the earlier epoch. It had gained in generality and begun to apply some of its results to physical science or to the philosophic thought thus helping both subjects to grow. Arabic notation of decimal system, Hindu developments of Algebra and Trigonometry had been already contributed by Asiatic thought. Thus arose tbe idea of a function of one or more symbols (these symbols being letters called arguments or variables). Algebra thus develops into the general science of analysis in which we consider the properties of various functions of variables. Finally the simple known functions like the algebraic functions, logarithmic functions and trigonometrical functions suggested the idea of any function; the rise of algebraic analysis led to Descartes' discovery of Analytical Geometry and then to the Infinitesimal Calculus by Newton and Leibnitz. There is no sharp distinction between algebraic analysi sand the Infinitesimal Calculus except that the latter involves the process of limits.

In the 17th century this idea of a general function was dominant in the abstract sphere of mathematics and enabled mathematicians to put the laws of nature in nice and elegant forms. Mathematics thus supplied the background of imaginative thought with which the men of science approached the observation of Nature. Galileo produced formulae, Descartes and Newton did the same. It was only in the last century that the increasing complexity of both the subjects, Mathematics and Physics, produced the separation of the two departments. In the 17th and 18th century the Mathematician and Physicist were one and the same man. Mathematical thinking has played a very important part in the formation of the fundamental concepts of the Physicist. Take for example the conception of Energy and the exact meaning of the great generalisation known to us as the Principle of conservation of Energy. This principle was the direct outcome of the development of the abstract side of molar mechanics which enabled us to define K. E. & P. E. as work in measurable quantities. This mathematical expression was so elegant and so apt that it naturally got extended to the molecular domain. The doctrine of the conservation of Energy was a necessary presupposition of further development for Joule and Mayer, who regarded heat as a form of energy. Joule was able to determine the mechanical equivalent of heat only because the mechanical work was already regarded as a measurable quantity. The notion of Potential which is a fundamental

subject in Electromechanics and which is constantly employed by every electrical engineer was first developed as a mathematical conception during the 18th century in connection with the theory of attractions of gravitating bodies. It was transferred to the electrical domain by Green and others together with a good deal of detailed mathematics applicable to the potential function.

Another example of the effect of the abstract development of mathematics of the Science of those times was the notion of periodicity. We are all familiar with recurrence in our ordinary experience. Days recur, lunar phases recur, the seasons of the year recur and beats of the heart recur. The recurrence forms the fundamental basis of our knowledge. Thus in the 16th and the 17th centuries, the theory of periodicity took a fundamental place in Science. Kepler divined his three famous laws about the orbits of the planets and the periods in which the planets described their orbits. Galileo observed the periodic vibrations of pendulums. Newton explained sound as being due to the disturbance of air by the passage through it of periodic waves of condensation and rarefaction. Huyghens explained light as being due to the transverse waves of vibrations of a subtle ether. Mersenne connected the period of the vibration of a violin string with its density tension and length. The birth of modern Physics depended on the application of the abstract idea of periodicity to a variety of concrete examples.

Now the Science of Trigonometry arose long ago from the ratios between the side and hypotenuse of the right angled traingle. But under the influence of the general idea of functions it broadened out into the study of the simply abstract periodic functions. Thus trigonometry became abstract and hence useful. The theory of representation of a function of a real variable by means of trigonometric series has revolutionised the whole mathematical world. It is an indispensable weapon in the hands of a physicist and at the same time has exercised the most far-reaching influence upon the development of modern mathematical Analysis. It is indeed very surprising that as mathematics withdrew increasingly into the Heavens of great extremes of thought, it returned to the Earth with a corresponding growth of importance for the analysis of concrete fact. It seems clear now that the utmost abstractions are the true weapons with which we are to control our thought. The theory of sets of points arose directly from questions connected with trigonometric series. The precise formulation by Rieman of the conception of definite integral and the gradual development of the modern notion of a function as existent independently of any special mode of representation by an analytical expression, are further examples of the results of the study of the properties of these series upon mathematical analysis. It is significant,

however, all this had its origin in the attempt to investigate the form of a stretched string in a state of vibration. This eventually led to theory of Fourier Series.

Fourier himself did not give any complete general proof of the convergence of the Series to the value of the function. Although this problem arose from the applications to the physical phenomenon, the problem of convergence has given such an impetus to the development of the Theory of Functions. It is out of place here to narrate the whole history of the theory of Fourier Series and the brilliant researches from the point of view of abstract thought, it has led to uptil now. The subject is by no means closed even now; but I shall simply point out the ultimate progress of humanity such problems lead to. A pure mathematician is never satisfied with the Fourier Series which converges everywhere normally. Very often a mathematician's generalisation from a non-utilitarian point of view has led to astounding results. Early in the last century some of the brilliant mathematical physicists were engaged in establishing the relation between the phenomenon of Electricity and of Magnetism. They were solely actuated by intellectual curiosity in bridging the gulf between the two important phenomena. Had their spirit been utilitarian, they would have probably left the matter on one side as holding out no prospect of useful application. At last it was found that Electricity in motion produced the same effects as magnets at rest, and vice versa. The result of this discovery has enabled us to have such physical comforts as motor cars, the telephone, and the electric telegraph and various other things.

Though an all round progress was made in the 19th century in Pure mathematics, the influence of mathematics upon the general thought of the age was not considerable. Its influence was on dynamics and physics and consequently on engineering and chemistry. Yet it is difficult to overrate its indirect influence on human life through the medium of these sciences. Since the technique had been perfected its progress was easy though uninteresting.

On a retrospect we see that there are two great periods of direct influence on the history of Mankind. The first period was that stretching from Pythagoras to Plato when the possibility of the Science and its general character dawned upon the Grecian thinkers. The second period comprised the 17th and the 18th centuries of our modern epoch. In both the periods there was an awakened curiosity and a movement towards the reconstruction of traditional ways. Critical scientific interest was present in both the periods. The parallel between the two epochs must not be pressed too far. The modern world is larger and more complex than the ancient one. We are now entering upon an age of reconstruction in religion, in science and in political thought.

If we are to avoid mere ignorant oscillation between extremes, we are to seek truth in its ultimate depths. There can be no vision of this depth of truth except in a sound philosophy which takes full account of those ultimate abstractions, whose interconnections it is the business of mathematics to explore.

THE INFINITE IN MATHEMATICS*

By

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" *But what has been said once, can always be repeated.*"

—Zeno of Elea, as quoted by Simplicius.

1. *Concept of Infinity Indispensable to Mathematics*

Modern analysis is nothing but the theory of infinite processes, where by an infinite process I mean a set of operations which produces an infinite sequence. On a little reflection, the statement will be obvious. The arithmetic continuum forms the central pillar that supports modern analysis ; and this central pillar could not have been constructed but for the work put in by great artists like K. Weierstrass (1815-1897), R. Dedekind (1831-1916), and G. Cantor (1845-1918). In putting the theory of irrational numbers on an arithmetical basis both Cantor and Dedekind start from the domain of rational numbers. But in arriving at the domain of real numbers, the arithmetic continuum, the former explicitly uses an infinite process while the latter employs the principle of partition imposed upon an infinite set of rational numbers.† Again one who is familiar with the Integral Calculus need not be told that even comparatively simple problems such as finding the length of a curvilinear arc, or the area enclosed by curved lines depend for their solutions upon an infinite process. And it is easy to go on indefinitely multiplying examples of this nature to show that the concept of infinity is indispensable to mathematics ; nay, it may be even asserted, without any fear of contradiction, that but for the concept of infinity, the science of mathematics would have been poorer by the loss of modern analysis. For we knew that the *method of exhaustion,* invented by Archimedes (287 ?—212 B. C.), contained all the elements essential to an infinitesimal analysis ; but the *horror infinite* which the arguments of Zeno instilled into the minds of the Greek mathematicians acted as an effective brake against all further progress in that direction for a period of no less than 1,850 years. It was reserved for J. Kepler (1571-1630) to lay down the foundations of our modern Integral Calculus by publishing his book *Nova Stereometria Doliorum* in 1615 in which he successfully used the method of

* The subject suggested itself to me on reading *Number* by Tobias Dantzig.

† For more information on this point *vide* writer's *Essays in Mathematics*, No. 1, §§ 32-34.

exhaustion, coupled with the notion of infinitely small and infinitely large quantities in determining areas and volumes of curved figures; and the present structure of modern analysis has been built only during the course of the last century.

2. Bounded Arithmetic and Bounded Geometry

Again but for the concept of infinity many an operation in our arithmetic and Euclidean geometry would not be possible. For instance, if we terminate the sequence of natural numbers 1, 2, 3, ... at a psychological limit of the counting process, say at 1,000,000, the operations of addition and multiplication such as 500,000 + 500,001 and 1,000 × 1,001 would be impossible in such a finite and bounded arithmetic. Similarly in geometry, should it be necessary to confine ourselves to a finite and bounded plane, it would be entirely a matter for speculation whether or no two straight lines taken at random form an angle, or three, a triangle.

3. Concept of Infinity has no Experiential Basis

Now though these primary mathematical operations of telling and measuring, leading as they do to the theory of number and of geometry, had their origin, like all other sciences, in the practical needs of man living in the physical world, all our experience of this physical world cries out the falsity of the concept of infinity. The tremendous progress that we have achieved in experimental sciences clearly indicates that there is no experimental basis for the said concept. The closing months of the last century witnessed the discovery of the Quantum Theory by M. Planck. Planck propounds that the radiant energy does not flow continuously and is not capable of being divided indefinitely, as every continuous matter should be, and that it is emitted in integral quantities or bundles, known as quanta. The recent researches carried on by Rutherford and Bohr regarding the structure of an atom lead us to the conclusion that matter is not subject to the process of infinite divisibility; it ultimately consists of electrons and protons which have finite sizes. Thus "wherever the method of investigation of matter has been carried sufficiently far, we have invariably struck a limit of divisibility, and this was not due to a lack of experimental refinement but resided in the very nature of phenomena." Again like infinite divisibility of matter—and energy is but matter in another form—"the infinitude of the universe" is now declared to be a myth. For Einstein's study of the cosmos from the view-point of his theory of gravitation leads to the possibility of a finite universe and the observations of the astronomers agree with his hypothesis of an elliptic universe.

4. Nor is it a Logical Necessity

Thus the concept of infinity is not an experiential necessity; nor is it a logical necessity. For by recasting and reconstructing

a few postulates and definitions of the present system of arithmetic it is possible to build up a conceptual scheme of finite arithmetic which will not be a whit inferior to the classical one for beauty of conception and internal harmony of logic. Similarly by omitting the postulate of parallelism a system of bounded geometry can be constructed so as to produce a logically self-consistent conceptual scheme. And these two conceptual schemes of bounded arithmetic and bounded geometry will possess an additional merit of being closer to the reality of our senses than the unbounded ones which, being sanctified by custom, are suffered to exist. Now it is none of the business of the mathematician to enquire whether or no his logically self-consistent conceptual scheme possesses also the attribute of applicability to physical phenomena. It is the business of the physicist. For though undoubtedly the science of mathematics owes its origin to and looks upon the problems of physical sciences as sources of inspiration, the mathematician refuses to confine himself to the limits of the problems set by the physicist. These problems often give rise to a host of other questions for which his intellectual curiosity forces the mathematician to find answers and this need of his intellectual craving leads him far beyond the original domains in which these problems arise; and in this way the mathematician produces an abstract conceptual scheme which is subject to no other test except that of logical coherence. The most abstract branches of modern mathematics such as the theory of functions of real and complex variables, the theory of differential equations had their genesis in problems of physics.* Moreover the mathematician does not take the utilitarian view of his science as the physicist does. With him the motto is: Mathematics for Mathematics' sake. Indeed it would be very instructive to compare the attitude of the physicist and the mathematician towards mathematics. But I do not hold that this is the proper place for it. Therefore, for the present, suffice it to say that the utilitarian view of any science, apart from the fact that it strangles the progress of that science, is not an absolute test; for the standard of what constitutes utility is a *function* of time. The study of conic sections originated in the practical problem of doubling the altar. But had the Greek geometricians taken the utilitarian view of the subject and had they not been goaded by their intellectual curiosity to study conic sections as an abstract science, Kepler could not have been able to formulate his famous trio of laws that govern the motion of the planets in the solar system. And but for Kepler there would not have been any Newton and but for Newton there would not have been any Einstein. Similiary G. F. B. Riemann (1826-1866) hardly dreamt

* See *Essays in Mathematics* No. 1,§§12–16 where I have historically traced the growth of the present concept of function.

that his absolute differential calculus would one day become the vehicle for Einstein's theory of Relativity.

5. *Concept of Infinity a Mathematical Necessity*

In the preceding paragraphs I have endeavoured to show that the concept of infinity has neither a physical foundation nor a logical basis. Then what is it that lies behind this concept? The concept of infinity is neither an experiential nor a logical necessity; it is a mathematical necessity, a being owning its birth to the creative imagination of the mathematician who is endowed with that power of mind which is capable of conceiving the indefinite repetition of an act when this act is but once possible. The condemnation of this concept in the name of reality "would reduce mathematics to the bounded arithmetic and the bounded geometry . . . . What is valid seems so insignificant that it may be seriously doubted whether analysis is at all possible. The lofty structure erected by the mathematicians of the last three centuries must be razed to the foundation; the principles and methods which derived their power from the use of the infinite must be scrapped; the physcial sciences which have so confidently applied the concepts of limit and function and number in formulating and analyzing their problems must turn over a new leaf; they must rebuild their foundations and devise new instruments in lieu of those condemned."

6. *The Infinite, Potential and Actual or Dynamic and Static*

Our present concept of the infinite rests on a fundamental assumption of arithmetic, *viz.* the process of counting cannot conceivably be terminated. In other words the sequence of natural numbers 1,2,3, ... does not possess the last number; each number has a successor or there is an infinity of positive integers. Or again, if we consider n to be a positive integer, the pharse n tends to infinity is a short-hand way of saying that given a positive number $\triangle$, however large, n assumes values that exceed and remain greater than $\triangle$. This traditional concept of the infinite as a *variable* finite magnitude that grows indefinitely is often called the concept of the potential infinite in contradistinction to that of the actual infinite which is a *fixed*, *constant* quantity lying beyond all finite magnitudes. This concept of the actually infinite is not of recent origin. The celebrated analysts K. F. Gauss (1777-1855) and A. L. Cauchy (1789-1857) raised their protesting voice against the use of the actual infinite in mathematics. In his letter written to Schumacher in 1831 Gauss writes: "As to your proof, I must protest most vehemently against your use of the infinite as something consummated as this is never permitted in mathematics." The infinite is but a *façon de parler*; "an abridged form of the statement that limits

exist which certain ratios may approach as closely as we desire, while other magnitudes may be permitted to grow beyond all bounds." It required the courage of G. Cantor (1845-1918) to defy old traditions and "deal with the actually infinite as with a definite mathematical being." In his essay *On Linear Aggregates*, published in 1883 Cantor writes: " It is traditional to regard the infinite as indefinitely growing............... As against this I conceive the infinite in the definite form of something consummated, something capable not only of mathematical formulations, but of definition by number. This concept of the infinite is opposed to traditions which have grown dear to me, and it is much against my own will that I have been forced to accept this view. But many years of scientific speculation and trial point to these conclusions as to a logical necessity, and for this reason I am confident that no valid objections will be raised which I shall not be in a position to meet."

7. *The Transfinite Arithmetic.*

The creative imagination of Cantor did not remain content with conceiving the infinite as capable of definition by number; it impelled him to evolve a system of comparing infinities. By introducing the concept of cardinal numbers we are able to compare two finite collections and say that they are equal or one is smaller than the other. Similarly by introducing the concept of power of an infinite aggregate Cantor is able to compare two infinite aggregates. These powers, which enable us to classify infinities just as the finite numbers 1, 2, 3, ... enable us to classify finite collections, are known as transfinite numbers. By defining the operations of addition, multiplication and potentiation upon these transfinite numbers Cantor created a transfinite Arithmetic, an arithmetic of the infinite.

8. *Common sense and the Infinite.*

But it must be remembered that certain fundamental *Common-sense* laws, which we find hold good in finite arithmetic, do no longer remain true if we transfer them to transfinite arithmetic; for in considering infinities we are really traversing a region that lies beyond the realm of common sense, and further, many a time in mathematics common sense has proved to be the greatest non-sense. While we are dealing with finite collections common sense tells us that a part is less than the whole. But in comparing infinities the fundamental rule is: The part *can* equal the whole; the part *may* have the power of the whole. For example, the two aggregates formed by the natural sequence and the odd integers are both infinite and the latter is a part of the former; yet it can be proved that both the aggregates have the same power. On the other hand, though the domain of rational numbers forms a part of the arithmetic continuum, the continuum is migh-

tier than the domain of rational numbers; the power of the latter is greater than that of the former.

9. *Concept Craves Clarification*

The purpose of this article does not justify me in going into more details regarding the transfinite arithmetic; and I propose to conclude this essay by briefly indicating the present position concerning the concept of the infinite. The legitimacy of Cantor's use of the actually infinite in mathematics, the logical validity of his processes and the deductions drawn thereby have been put to searching criticism by leading mathematician-philosophers of the day. Among them Burali-Forti, Bertrand Russell, König and Richard are prominent; and their discussions have given rise to paradoxes and antinomies that are either logical or linguistic. As stated above Cantor said, "No valid objections will be raised which I shall not be in a position to meet." Well; the Cantorians have not only failed to meet these valid objections and to convert all mathematician-philosophers to their point of view, but on the contrary, some of the Cantorians such as F. P. Ramsey (1903-1930) are being converted to a finitist view which rejects the concept of the actually infinite. In his address in memory of K. Weierstrass, one of the greatest exponents of the movement known as arithmetization of mathematics, D. Hilbert says: "The infinite! No other question has ever moved so profoundly the spirit of man; no other idea has so fruitfully stimulated his intellect; yet no other concept stands in greater need of clarification than that of the infinite."

NOTE ON CONFOCAL CONICS AND CONFOCAL QUADRICS

By

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I think that the following method of obtaining the equation to the system of conics or quadrics confocal with a conic or quadric given by the most general equation of the second degree has not received the attention it deserves.

1. Notation: Let $s \equiv (a,b,c,f,g,h)(x,y,z)^2 = 0$ be the given conic. z may be conveniently replaced by unity.

Let $$2\xi \equiv \frac{\partial s}{\partial x},\ 2\eta \equiv \frac{\partial s}{\partial y},\ \text{and}\ 2\zeta \equiv \frac{\partial s}{\partial z}.$$

The envelope equation to the given conic $s=0$ is

$S \equiv (A,B,C,F,G,H)(X,Y,Z)^2 = 0$ where A, B etc., have the usual meanings and X, Y, Z are line co-ordinates.

The circular points at infinity are given by

$$\Omega \equiv X^2 + Y^2 = 0$$

2. I will first prove that the equation

$$\begin{vmatrix} a+\lambda & h & \xi \\ h & b+\lambda & \eta \\ \xi & \eta & s \end{vmatrix} = 0$$

gives us the family of conics confocal with the given conic $s=0$, λ being the parameter of the family.

We know that the four vertices of the quadrilateral formed by the two pairs of tangents that can be drawn from the cirular points at infinity to the conic $s=0$ give us the four foci of $s=0$. Since the equation $S+k\Omega=0$, where k is any arbitrary constant, gives us the family of conics touching the common tangents of $S=0$ and $\Omega=0$, and further, since $\Omega=0$ gives us the circular points at infinity, it follows that the family of conics given by $S+k\Omega=0$ has the same foci as those of $S=0$. In other words $S+k\Omega=0$ is the envelope equation to the family of conics confocal with $s=0$. Now we know that the locus equation to the said family is found to be

$$\sigma \equiv \begin{vmatrix} A+k & H & G & x \\ H & B+k & F & y \\ G & F & C & z \\ x & y & z & 0 \end{vmatrix} = 0$$

Multiplying both sides of $\sigma = 0$ by $\delta \equiv \begin{vmatrix} a & h & g & 0 \\ h & b & f & 0 \\ g & f & c & 0 \\ 0 & 0 & 0 & 1 \end{vmatrix}$ we get

$$\sigma \cdot \delta \equiv \begin{vmatrix} \delta + ak & hk & gk & x \\ hk & \delta + bk & fk & y \\ 0 & 0 & \delta & z \\ \xi & \eta & \zeta & 0 \end{vmatrix} = 0^*$$

Multiplying the columns of the last determinant by x, y, z and $-\delta$ respectively, and adding the results for the fourth new column, we get

$$\sigma \equiv \begin{vmatrix} a+\delta/k & h & \xi \\ h & b+\delta/k & \eta \\ \xi & \eta & s \end{vmatrix} = 0$$

Setting $\delta/k = \lambda$, we get the desired result.

3. The same method holds true *mutatis mutandis* in three dimensions. Let the quadric be given by

$$s \equiv (a, b, c, d, f, g, h, u, v, w)\,(x, y, z, t)^2 = 0$$

where t may be conveniently replaced by unity. The envelope equation of the quadric $s = 0$ is

$$S \equiv (A, B, C, D, F, G, H, U, V, W)\,(X, Y, Z, T)^2 = 0.$$

The circle at infinity is represented by the equation

$$\Omega \equiv X^2 + Y^2 + Z^2 = 0.$$

We now know that $S + k\Omega = 0$ is the envelope equation to the family of quadrics confocal with the quadric $S = 0$. Proceeding as before, the locus equation to the said family is found to be

* This equation may be written as

$$\delta s - k\Gamma + k^2 = 0$$

where $\Gamma \equiv C\,(x^2+y^2) - 2\,Gx - 2\,Fy + A+B = 0$ gives us the director circle of the conic $s = 0$.

$$\begin{vmatrix} a+\lambda & h & g & \xi \\ h & b+\lambda & f & \eta \\ g & f & c+\lambda & \zeta \\ \xi & \eta & \zeta & s \end{vmatrix} = 0$$

where $2\xi = \frac{\partial s}{\partial x}$, $2\eta = \frac{\partial s}{\partial y}$, $2\zeta = \frac{\partial s}{\partial z}$ and $\lambda = \delta/k$

δ being the determinant $|\ a\ b\ c\ d\ |$.

A NOTE ON THE AREA OF A POLYGON

By

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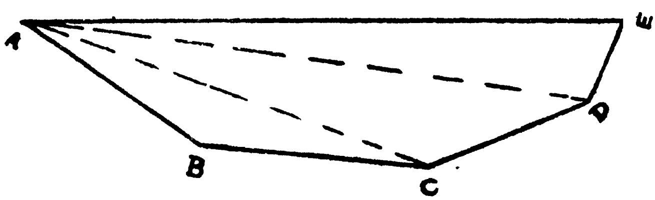
This note contains an alternative proof of the following theorem. It is neat and elegant and is calculated to stimulate interest in the study of methods of Vector Analysis.

We shall prove the theorem, in the first instance, with respect to the polygon A B C D E.



Let us denote the vectors AB, BC, ... EA by α, β, ... ϵ; their lengths by $a, b, \ldots e$; the angle which β makes with α by $\alpha\beta$ and the unit vector normal to the plane of the polygon, by ν. Join AC, AD.

Then $2\nu \, \triangle \, ABC = \overline{AB} \times \overline{AC} = \alpha \times (\alpha+\beta) = \alpha \times \beta$.

Similarly $2\nu \, \triangle ACD = (\alpha+\beta) \times \gamma$.

$$2\,\nu\triangle ADE = (\alpha + \beta + \gamma) \times \delta.$$

Also $\qquad 0 = (\alpha + \beta + \gamma + \delta) \times \epsilon$

Hence $\quad 2\nu \times$ Polygon ABCDE $= \Sigma\, \alpha \times \beta$

$$= 2\nu \quad \Sigma\, ab \sin \alpha\beta$$

where the sum includes all terms corresponding to combinations of $\alpha, \beta, \ldots$ taken two at a time and where the alphabetical order of factors is maintained in each term.

Hence Polygon ABCDE $= \Sigma\, ab \sin \alpha\beta$.

The foregoing method can be extended to any polygon.

c. f. Hobson's Trigonometry §129.
Also Bagi's Plane Trigonometry §131.

SOME POINTS ABOUT ORDINARY LINEAR DIFFERENTIAL EQUATIONS

By

G. S. DIWAN

(i) *Operational Factors.*

In solving ordinary linear differential equations of the second order by the method of operational factors, the following proposition is useful:—

If the operator $P_0D^2+P_1D+P_2$ in the linear differential equation $P_0\frac{d^2y}{dx^2}+P_1\frac{dy}{x}+P_2y=X$ is *algebraically* equivalent to $(aD+\alpha)(bD+\beta)$, and if b and β are constants (*i.e.*, do not involve x), then even *operationally* $P_0D^2+P_1D+P_2$ is equivalent to $(aD+\alpha)(bD+\beta)$, the two operational factors appearing in this very *specific order.* $(D\equiv\frac{d}{dx})$.

Proof:—If $P_0D^2+P_1D+P_2\equiv(aD+\alpha)(bD+\beta)$ *algebraically*, then $P_0\equiv ab$, $P_1\equiv a\beta+b\alpha$, and $P_2\equiv\alpha\beta$. The operator $(aD+\alpha)(bD+\beta)$ operating on y gives the result $(aD+\alpha)(b\frac{dy}{dx}+\beta y)$, *i.e.*, $ab\frac{d^2y}{dx^2}+\frac{dy}{dx}(ab'+a\beta+b\alpha)+(\alpha\beta+a\beta')y$. $\left[b'=\frac{db}{dx}\text{ and }\beta'=\frac{d\beta}{dx}\right]$ $(aD+\alpha)(bD+\beta)$ is, therefore, operationally equivalent to, say, $Q_0D^2+Q_1D+Q_2$, where $Q_0\equiv ab$, $Q_1\equiv a\beta+b\alpha+ab'$, and $Q_2\equiv\alpha\beta+a\beta'$. $(aD+\alpha)(bD+\beta)$ will, therefore, algebraically and operationally be equivalent to the same expression if $P_0\equiv Q_0$, $P_1\equiv Q_1$, and $P_2\equiv Q_2$; *i.e.*, if ab' and $a\beta'$ are each equal to zero, which is seen to be true when b and β are constant quantities.

It can also be seen that under no other circumstances are the algebraical and the operational factors of $P_0D^2+P_1D+P_2$ just the same.

(ii) *Particular Integral.*

[It is thought that the following notes will make some points of the theory of the particular integral of an ordinary linear differential equation clearer.]

(A) The particular integral of the ordinary linear differential equation $p_0\frac{d^ny}{dx^n}+p_1\frac{d^{n-1}y}{dx^{n-1}}+p_2\frac{d^{n-2}y}{dx^{n-2}}+\quad\cdots\quad+p_{n-1}\frac{dy}{dx}+p_ny=X$

can be *uniquely* defined as that solution of the above differential equation which does not involve as part of itself any non-zero value of the Complimentary Function (C. F.) which equated to y forms the general solution of $p_0\frac{d^ny}{dx^n}+p_1\frac{d^{n-1}y}{dx^{n-1}}+p_2\frac{d^{n-2}y}{dx^{n-2}}+ \dots\dots\dots\dots + p_{n-1}\frac{dy}{dx} + p_ny=0.$

[If the two equations above are written as $f(D)y=X$ and $f(D)\ y=0$, then it is seen that if u and v are, if possible, two particular integrals (as defined above) of $f(D)y=X$, $f(D)u=f(D)v=X$, and, therefore, $f(D)\ (u-v)=0$. $y=u-v$, therefore, is a solution of $f(D)y=0$. $u-v$ is thus a value of the C. F. which equated to y forms the general solution of $f(D)y=0$. Since neither u nor v can contain as part of itself any non-zero value of the C. F. by the definition as stated above, it follows that $u-v$ must be the zero value of the C. F. u, therefore, must be identically the same as v; *i.e.* with the above definition there can be only one particular integral for a given ordinary linear differential equation.]

(B) If the particular integral of $f(D)y=X$ is, as usual, denoted by $\frac{1}{f(D)}X$ by defining the result of an inverse operation in the appropriate manner, then with the definition given in (A), it shall have to be understood that the result $\frac{1}{f(D)}X$ is not to involve as part of itself any non-zero value of the C.F. which equated to y is the general solution of $f(D)y=0$. The value of the result $\frac{1}{f(D)}f(D)X$ will, therefore, strictly be *not always* X, but in every case $X-X'$, say, where X' is either the *whole* of the non-zero value, if any, of the C.F. contained as part in X, or else zero if there is no such non-zero value contained in X. (This statement can be formally established as follows:—Let $\frac{1}{f(D)}f(D)X=u$, say; then $f(D)u=f(D)X$, *i.e.*, $f(D)\ (u-X)=0$. $u-X$, therefore, is a value of the C·F·. u by definition cannot contain a non-zero value of the C·F·. If X also does not contain any such non-zero value of the C.F., then $u-X\equiv0$, or $u\equiv X-X'$ where X' is zero. If X does contain a non-zero value X', say, of the C·F·, and no other such non-zero value, then $u-X\equiv-X'$ *i.e.* $u\equiv X-X'$ where X' is the *whole* of the non-zero value of the C.F. contained in X.) In §60 of the sixth chapter of Murray's Differential Equations the result $\frac{1}{f(D)}e^{ax}=\frac{e^{ax}}{f(a)}$ is established as valid when $f(a)\neq0$. If the result is thus not valid when $f(a)=0$, the process leading to the result must also at some stage or the other not be

applicable when $f(a)=0$. It will probably help the clear understanding of the point if it is noted that the step $\frac{1}{f(D)} f(D) e^{ax} = \frac{1}{f(D)} f(a) e^{ax}$ in the process leading to the result reduces to the identity $0=0$ when $f(a)=0$ (e^{ax} being a non-zero value of the C.F. in this case), and thus fails to give any result in the exceptional case when $f(a)=0$.

(C) With the special meaning assigned in (B) to the result of an inverse operation as denoting a particular integral, it follows that if $\Psi(D)$ and $f(D)$ are operators operating on y in ordinary linear differential equations with *constant* coefficients, then $\Psi(D) \frac{1}{f(D)} X = \frac{1}{f(D)} \Psi(D) X$ *only if the expression on the left-side does not involve as part of it any non-zero value of the* C.F. *corresponding to the equation* $f(D)\, y=0$. There are cases in which such a non-zero value of the C·F· is involved as part in the left side. Consider, for instance, $D \cdot \frac{1}{D^2+1} \cos x$, which is equal to $\frac{\sin x}{2} + \frac{x \cos x}{2}$. This value involves as part of itself the term $\frac{\sin x}{2}$, which is a non-zero value of the C.F. corresponding to the equation $(D^2+1)\, y=0$. $\frac{1}{D^2+1} D \cos x = -\frac{1}{D^2+1} \sin x = \frac{x \cos x}{2}$. So it is seen in this case that $D \cdot \frac{1}{D^2+1} \cos x \neq \frac{1}{D^2+1} D \cos x$, for the left side contains as its part some non-zero value of the C.F. corresponding to $(D^2+1)\, y=0$.

In §64 of the sixth chapter of Murray's Differential Equations the formula $\frac{1}{f(D)} x V = x \frac{1}{f(D)} V - \frac{1}{f(D)} f'(D) \frac{1}{f(D)} V$ is deduced. The last term on the right side of this formula is often taken as $-f'(D) \cdot \frac{1}{[f(D)]^2} V$ or as $-\frac{1}{[f(D)]^2} f'(D)\, V$*. We may call these two modifications of the formula modifications (α) and (β) respectively. It will now be seen that such a modification is not *always* correct as the direct operator $f'(D)$ and the inverse operator $\frac{1}{f(D)}$ are not *always* commutative. Where such a modification is not correct, the use of the formula in either of the forms (α) or (β) instead of in the original form (which is *always* correct) leads to an error. Such a case practically arises when $f(D)$ is a power of

* See Jhonson's *Treatise on Differential Equations* (3rd edition), page 117.

(D^2+a^2) and V is the trigonometric function $\cos ax$ or $\sin ax$. In the footnote given on page 123 of the third edition of Jhonson's treatise on Differential Equations, it is said that in cases analogous to the evalution of $\frac{1}{D^2+a^2}x\cos ax$, the method that 'should always be employed' is to consider $\frac{1}{D^2+a^2}x\cos ax$ as the real part in $\frac{1}{D^2+a^2}xe^{axi}$; and that 'an error might arise' if the method of §64 in Murray's book is used. In this connection it is to be noted that the error arises *only* if form (α) or (β) of the formula (both of which forms are as shown above incorrect in such cases) is used, and the formula in its ***original*** form gives correctly the value of a particular integral of the type $\frac{1}{(D^2+a^2)^r}x^s$ V, where r and s are positive integers and $V=\cos ax$ or $\sin ax$. To illustrate the point the result $\frac{1}{D^2+a^2}x\cos ax$ is worked out in full below :—

$$\frac{1}{D^2+a^2}x\cos ax=x.\frac{1}{D^2+a^2}\cos ax-\frac{1}{D^2+a^2}2D\frac{1}{D^2+a^2}\cos ax$$

$$=x\cdot\frac{x\sin ax}{2a}-\frac{1}{D^2+a^2}2\cdot\frac{1}{2a}(\sin ax+ax\cos ax)$$

$$=\frac{x^2\sin ax}{2a}-\frac{1}{D^2+a^2}x\cos ax-\frac{1}{a}\cdot\frac{1}{D^2+a^2}\sin ax$$

$$\therefore\ \frac{2}{D^2+a^2}x\cos ax=\frac{x^2\sin ax}{2a}+\frac{x\cos ax}{2a^2};\ i.e.,$$

$$\frac{1}{D^2+a^2}x\cos ax=\frac{x^2\sin ax}{4a}+\frac{x\cos ax}{4a^2}.$$

Had the modified form (α) been incorrectly used to evaluate the particular integral, the result would have been $\frac{x^2\sin ax}{4a}+\frac{x\cos ax}{2a^2}$ and if form (β) were used the result would be merely $\frac{x^2\sin ax}{4a}$.

It should also be remarked that though $x\cos ax=-2a\cdot\frac{1}{D^2+a^2}\sin ax$, still $\frac{1}{D^2+a^2}x\cos ax$ is not $=-2a\cdot\frac{1}{(D^2+a^2)^2}\cdot\sin ax$, which latter is seen to be equivalent to $\frac{x^2\sin ax}{4a.}$ The reason for this non-equivalence is that $\frac{1}{f(D)}$ $\Big[$the function of x given by $\frac{1}{f(D)}X\Big]$ is

equal to $\frac{1}{[f(D)]^2}$ X only if the former does not involve a non-zero value of the C. F. corresponding to the equation $[f(D)]^2 y = 0$.

If the second term on the right side of the modified form (α) is taken as $-f'(D) \cdot \frac{1}{f(D)}\left[\frac{1}{f(D)} V\right]$, then the value of the particular integral so obtained in the exceptional cases indicated above will not in itself be incorrect but will be involving some non-zero value of the C.F. Such a method, however, is not practical; since in the evalution of $\frac{1}{f(D)}\left[\frac{1}{f(D)} V\right]$ where, say, $V = \cos ax$ and $f(D) = (D^2 + a^2)$, the use of the original form of the formula in §64 of Murray's book appears to be necessary. Similarly if the modified form (β) is taken with the second term on the right side as $-\frac{1}{f(D)}\left[\frac{1}{f(D)} f'(D) V\right]$ then the value of the particular integral so obtained in the exceptional cases will be incorrect.

A NOTE ON THE PROPER NOMENCLATURE FOR "*VRAIE VALEUR*"

By

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If a functional form $f(x)$ becomes indeterminate for a value $x=a$, but limit $f(x)$ as $x \to a$ exists, Vallée Poussin calls the limit "*Vraie Valeur*" of the function at $x=a$ (Cours d'Analyse, Vol. I, §82), This has been translated into English as "*true value*" by Gibson (*Elementary Treatise on the Calculus*, p. 418) and Mahajani's (*Lessons in Analysis*, p. 70).

It seems that the term "*Vraie Valeur*" or "*true value*" is unfortunate and somewhat misleading. Other terms which would be less objectionable may be suggested, such as "*natural value*" or '*appropriate value*" or "*fitting value*". Personally I consider *appropriate value*" as the most natural, appropriate and fitting and would recommend it for general adoption.

A NOTE ON THE GENERAL EQUATION OF THE SECOND DEGREE WHEN IT REPRESENTS TWO PLANES

By

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In ex. 8 page 34 of Bell's Solid Geometry the condition that the General Equation $ax^2 + by^2 + cz^2 + 2fyz + 2gzx + 2xhy = 0$, represents two planes is mentioned and the student is at a loss to understand why the more general case of $ax^2 + by^2 + cz^2 + 2fyz + 2gzx + 2hxy + 2ux + 2vy + 2wz + d = 0$ when it represents two planes should not be discussed. No doubt the discussion has its place in Chapter XI; but the method involved is longer and cannot be picked up easily in the earlier stages.

Bell mentions the conditions on page 217 of his book but these are not explicit. An attempt is made here to express these conditions and to deduce them from very elementary considerations without the help of much mathematical analysis.

As shown by Bell the conditions practically reduce to those required for the four planes.

$$\begin{aligned} ax + hy + gz + u &= 0 \\ hx + by + fz + v &= 0 \\ gx + fy + cz + w &= 0 \\ ux + vy + wz + d &= 0 \end{aligned}$$

to pass through one and the same st. line.

Hence these may be written as :—

$$(i) \left\| \begin{matrix} a & h & g & u \\ h & b & f & v \\ g & f & c & w \end{matrix} \right\| = 0 \quad (ii) \left\| \begin{matrix} a & h & g & u \\ h & b & f & v \\ u & v & w & d \end{matrix} \right\| = 0$$

The first of these is equivalent to any two of four determinants being equal to zero, which may be written as $D = 0$, $K_1 = 0$, $K_2 = 0$ $K_3 = 0$ where

$$D = \begin{vmatrix} a & h & g \\ h & b & f \\ g & f & c \end{vmatrix} \qquad K_1 = \begin{vmatrix} a & h & u \\ h & b & v \\ g & f & w \end{vmatrix}$$

$$K_2 = \begin{vmatrix} a & g & u \\ h & f & v \\ g & c & w \end{vmatrix} \qquad K_3 = \begin{vmatrix} h & g & u \\ b & f & v \\ f & c & w \end{vmatrix}$$

If any two of these are satisfied the others are also automatically satisfied. The second is similarly equivalent to any two of the four determinants involved, *viz.*,

$$K_1 = 0, \ \Delta_1 = 0, \ \Delta_2 = 0, \ \Delta_3 = 0$$

where $\Delta_1 = \begin{vmatrix} a & h & u \\ h & b & v \\ u & v & d \end{vmatrix} \qquad \Delta_2 = \begin{vmatrix} a & g & u \\ h & f & v \\ u & w & d \end{vmatrix}$

and $\Delta_3 = \begin{vmatrix} h & g & u \\ b & f & v \\ v & w & d \end{vmatrix}$

If any two of these are satisfied the others are also automatically satisfied.

Hence on the whole the conditions are equivalent to the following :—

$$D = 0$$

Any one of $K_1 = 0, \ K_2 = 0, \ K_3 = 0$;

Any one of $\Delta_1 = 0, \ \Delta_2 = 0, \ \Delta_3 = 0$.

It is easily seen that the conditions are equivalent to any three of the seven determinants equated to zero ; *viz.*,

$$D, K_1, K_2, K_3, \Delta_1, \Delta_2, \Delta_3$$

and may be taken as $\Delta_1 = 0$, $\Delta_2 = 0$, $\Delta_3 = 0$. The others follow as a matter of analysis.

This result is easily deducible from general considerations. Any section of the two planes is two st. lines. Hence if the sections by the planes $x = 0$, $y = 0$, $z = 0$ not passing through the same st. line are st. lines the equation must represent two planes. No other surface of the second degree has this property.

$$\therefore \quad ax^2 + by^2 + 2hxy + 2ux + 2vy + d = 0$$
$$ax^2 + cz^2 + 2gzx + 2ux + 2wz + d = 0$$
$$by^2 + cz^2 + 2fyz + 2vy + 2wz + d = 0$$

represent pairs of st. lines. Conditions for which are

$$\Delta_1 = \begin{vmatrix} a & h & u \\ h & b & v \\ u & v & d \end{vmatrix} = 0 \qquad \Delta_2 = \begin{vmatrix} a & g & u \\ g & c & w \\ u & w & d \end{vmatrix} = 0$$

$$\Delta_3 = \begin{vmatrix} b & f & v \\ f & c & w \\ v & w & d \end{vmatrix} = 0$$

as previously established. As can be seen from what has been said before that D = 0 automatically; and this disposes of, as a particular case, *ex.* 8 on page 34, referred to above.

DESCRIPTIVE MATHEMATICS

By

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I have been asked to write a note on a new course for First Year Mathematics which it is proposed from this year to make alternative to the usual course in Algebra, Geometry and Trigonometry. It is entitled "Descriptive Mathematics", and is detailed as follows:

PAPER I.—Logarithms. The general quadratic. Graphs of $y=x^n$ for rational values of n, and of $y=a^x$, with applications. Graphs of

$$y=ax^m+bx^{m-1}+cx^{m-2}+\ldots\ldots\ldots\ldots\ldots\ldots\ldots+k.$$

Averages. Frequency distributions. Empirical probability. Binomial theorem for a positive integral index. Evaluation of determinants. Simple standard derivates and elementary integrals with applications.

PAPER II.—Slide scales. Similarity of triangles. Inversion. Nomograms. Graphical rulings. The determination of empirical formulæ. Graphical solution of equations. The radian. Circular functions and their graphs. Solution of triangles and simple two dimensional problems. Addition formulæ.

The suggestion to institute such a course came from the feeling that the more conventional syllabus in First Year mathematics was not fulfilling a generally useful purpose in the educational scheme. This feeling has also expressed itself in the plan for "bifurcation", under which mathematics as a subject in the First Year would no longer be compulsory, but would become merely an alternative which students who value it might choose. Teachers of mathematics share this feeling, and acquiesce in this negative solution. The ordinary course in mathematics may not be uninteresting, and it is doubtless valuable as a mental discipline to some students; but it is plain that it is not within the power of a large number of otherwise able students to profit from it to any satisfactory degree.

Yet the University of Bombay has seemed reluctant to follow the example of other Universities in adopting bifurcation of studies at so early a stage in order to avoid this danger of unprofitable drudgery. A remedy more adequate to the students' needs seems desirable, and the course in Descriptive Mathematics is an attempt to find *a more positive solution.* It is not inconsistent, however, with the proposal to "bifurcate", though the alternatives to be allowed may result in a

tendency to make the course cater for too narrow a class of student. It has to be realised that, while too frequently misuse occurs in applications of mathematical methods, the trend of all study and investigation in the modern world is such as to increase the importance of the part that mathematics plays in the search for truth. Accordingly it seems clear that a sustained effort should be made to give students as adequate an idea as possible of how mathematical devices, at least those of an elementary type, may be applied in appropriate ways to elucidate certain types of phenomena.

Thus far the investigations that have been made with this end in view have made two things abundantly clear. The first is the surprising range of *variety* often seen *in the applications* of the same mathematical tool. An example is given by equilateral-triangle rulings, sometimes called "architects' isometric paper". There are the well-known applications to three-component systems in engineering, in geology, and in chemistry, though the significance of the generalisation to multicomponent systems in the last is not so well-known. Also in physics use of the triangles is made in various ways, particularly in the study of colour. In dietetics certain properties of foods are conveniently represented on these triangles, and a distortion of the triangles makes possible a suggestive and comprehensive representation of aspects of metabolism. Equilateral triangles may be employed too in the study of types or changes in populations. Quite a different use of the same rulings is that for isometric drawings, and it has been found convenient in statistics as affording a comparatively easy means of scrutinizing and interpreting measurements of different types after regression values have been calculated.

The second result is that there is a *unity* and a development *in the mathematical principles*, on which are based those quantitative methods which are actually being applied, which constitute them a "body of knowledge" worthy to be compared with that in the more conventional mathematical course. Such a claim can be substantiated only after the new course has been fully tested in practice, but a glance at the detailed syllabus will show at least the possibility that there is actually in it something of the simplicity and the range which are aimed at in mathematical method.

It is not possible or fitting to examine here the proposed course in detail. Only some features of its relation to other branches of study may be mentioned. "Descriptive Mathematics", the title chosen to characterize the course, has a utilitarian bias. It indicates that endeavour is being made to deal with those mathematical devices which are found suitable for the description of quantitative phenomena or methods in different sciences. But signs are plentiful enough that what is emerging possesses considerable *cultural value*, not only for the student

who will turn to other studies with the knowledge that mathematics is more than an intricate system of abstractions and manipulations, but even for the student of mathematics who presumably has profited most from the ordinary course. After all, the ordinary course is but a continuation of the type of mathematics usually taught in schools, and it seems a deprivation further to confine the mathematical activities of a student with a flair for the subject to lines of approach with which he is already thoroughly familiarized. In the new course the clever mathematical student gets glimpses of possibilities of generalization and of application which give him an opportunity to exercise his powers to the full in a way that will often be illuminating in his later studies.

It appears that one of the most useful functions the new course may help to perform for students generally is to develop *the critical attitude.* An outstanding physiologist, who has found it necessary to use mathematics somewhat extensively in his researches, says that he finds that mathematics reveals to him, not so much what he should do, but rather what lines of investigation it may be fruitless to follow. It is probably true that aid to criticism comes from mathematics mainly through the variety of its methods making possible a scrutiny appropriate to a particular occasion; and in Descriptive Mathematics emphasis is repeatedly laid on the degree of fitness of an approach to a topic. Under the ordinary course an alternative proof is often regarded as merely a happy accident, useful in the verification of what had not been already clearly apprehended. There is need to extend greatly the idea that *flexibility of method* is something of essential worth, leading to a fuller appreciation of the meaning of the subject matter. But on occasion too criticism depends on ability to manipulate, and great stress is laid in the new course on methods which make it possible to push a calculation through to a definite stage where it may be regarded in relation to the other aspects of the matter. The need for a critical attitude may be illustrated from a standard textbook, Price's "Practice of Medicine". On page 414 thereof in detailing a calculation for the diet of a diabetic patient, the instruction is given to "divide by the arbitrary figure 30". The word "arbitrary" in itself arouses suspicion; yet this textbook in its third edition has no comment on this astonishing direction: it would seem almost obvious that it could have no application beyond the case of the patient under consideration. In applications of advanced mathematics it may often be that results have to be assumed without any appreciation of the way they have been obtained; but it can only lessen alertness if this attitude of acquiescence is allowed to apply to the most elementary processes. In this respect our training in mathematics should become but *an aid to commonsense.* It should be mentioned that when a distinguished professor

of mathematics in the north of England had the proposed course explained to him, his first comment was, "Well, this will certainly teach the students arithmetic!" He had found that his students, even those with mathematical ability, could not be trusted to be accurate in making calculations. Probably in this respect students in India are not any more reliable, and this is a practical defect which the ordinary course in mathematics does practically nothing to remedy.

There is *much still to be done* in discovering how mathematics may be most usefully employed in economics and in the sciences generally. At present it is evident there is much teaching that could be dispensed with, were students to come to their special studies with appropriate mathematical preparation. Statistics tends to be treated as an ornament to be added to knowledge acquired, instead of as a means to critical appreciation of such knowledge. Again, workers in the different sciences respond in curiously different ways to the suggestions of this course. Many botanists hail it as a possible means of removing obstacles that have long hindered them in the presentation of important aspects of their subject, while zoologists seem to see nothing in it that is related to their needs. I am assured that this is an historical accident and that the problems of botanists and of zoologists are essentially the same, though the latter are "still very much dominated by old morphological conceptions". This variety of response to Descriptive Mathematics but confirms the anticipation that the situation the course seeks to deal with is in some respects far from being defined. It is clear, however, that teachers of mathematics who, venturing along such lines as are indicated in Descriptive Mathematics, try to help non-mathematical students of the sciences to acquire more effective methods of study will find exhilarating surprises in store for them.

NOTE ON A METHOD OF SOLVING SPHERICAL BY PLANE TRIANGLES

By

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Having had occasion, in the course of certain Astronomical calculations, to obtain approximate solutions of a series of spherical triangles of a particular type, I was led to consider whether a method could be devised for the purpose, graphical or geometrical, which would give the results readily and with a fair degree of accuracy, say, correct within a quarter or a half of a degree. I found in my attempts that a spherical triangle can be connected with one or more of three plane triangles of a particular type which can be readily constructed geometrically from any three given elements of the spherical triangle. The geometrical construction is greatly facilitated by the use of a graduated quadrant of a circle (of radius = 10 cm. say) drawn on squared paper (divided into sq. millimetres).

I obtained the *connection between the spherical and the plane triangles* from certain projective properties of the sphere, the kind of projection used being simple but different from those in ordinary use. It can also be obtained and proved by using the ordinary formulae of Spherical Trigonometry.

2. Let P, Q be two intersecting planes and let the plane R pass through their common section and bisect the angle between them. Let X be any point and X′ its reflection in the plane R. Then

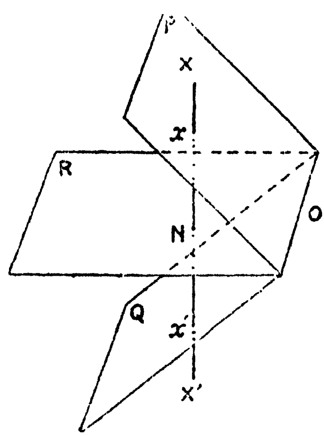


FIG. 1,

XX' is bisected by the plane R at right angles. If XX' intersects the planes P,Q in x,x' respectively, we shall for our present purpose, speak of x,x' as the *equi-sectional pojections of X with respect to the planes P,Q.*

Given two planes P, Q and *any figure V in a plane parallel to either of the planes,* we can by drawing st. lines through all the points of V, perpendicular to the plane R which bisects the angle between P,Q, obtain the projections V' and V'' of V on the planes P, Q. We shall speak of each of these as an equi-sectional projection of V with respect to the planes P, Q. (We shall neither use nor have occasion to use the term in the case of a figure V not in a plane parallel to P or Q).

3. The following simple *properties of equi-sectional projection* can be easily proved :—

(i) The equi-sectional projection of any st. line is a st. line of equal length.

(ii) The angle between the equi-sectional projections of two given st. lines is equal to the angle between them.

(iii) The equi-sectional projection of any curve or any portion of a curve is equal and similar in all respects to the original.

4. In applying this projection to points and lines connected with a sphere, I shall, with a view to avoid lengthy descriptions, use in what follows the usual astronomical terms for points and lines connected with the celestial sphere.

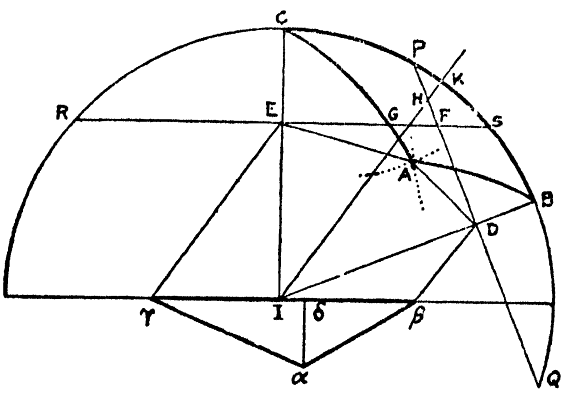


FIG. 2.

On the celestial sphere of centre I and radius unity, let A be a star, B the pole and C the zenith, the arc BC, a part of the meridian, being in the plane of the paper. Let D, E be the centres of the small circles, PAQ and RAS, of which the sph. radii are the arcs BA, CA respectively and of which the diameters PQ, RS in the plane of the meridian intersect in F,

Let K be the mid-point of the arc BC, so that IK bisects $\angle$ BIC. Then in projecting equi-sectionally with respect to the planes of the horizon and the equator we have to draw two st. lines parl. to IK. The projections on the plane of the horizon are shown in the figure as they would appear when that plane is rotated about the north-south line until it coincides with the plane of the paper.

Let α, β, Υ, δ denote the projections of A, D, E, F.

Then, in the Δ $\alpha\beta\Upsilon$,

$$\alpha\Upsilon = AE = ES, \quad \alpha\beta = AD = DP,$$
$$\angle\Upsilon = \angle AEF, \ \angle\beta = \angle ADF,$$
and since $\angle AFE = 90^\circ$, $\therefore$ $\alpha\delta$ is perp. to $\beta\Upsilon$.

5. Now, A,B,C and a,b,c being the angles and sides of the spherical triangle ABC, *the angles and sides of the plane triangle* $\alpha\beta\Upsilon$ are connected with them by relations which are obtained as follows :—

$\angle\beta = \angle ADP = \angle B$, (i); $\angle\Upsilon = \angle AES = \angle C$, (ii);

$\Upsilon\alpha = AE = \sin CIA = \sin b$, (iii);

$\beta\alpha = AD = \sin DIA = \sin c$, (iv).

Also, $I\Upsilon = IE \tan IE\Upsilon = \cos b \tan\frac{a}{2}$, (v);

$$I\beta = ID \sin ID\beta / \sin D\beta I$$
$$= \cos PID \sin BIK/\cos CIK = \cos c \tan\frac{a}{2}, \text{ (vi)};$$

whence, $\qquad \beta\Upsilon = (\cos b + \cos c)\tan\frac{a}{2} \quad . \ . \ . \ . \ . \quad$ (A)

6. The diameters PQ, RS of the small circles PAQ, RAS intersect in F. Let IK intersect RS in G and PQ in H.

Then, the equi-sectional projection of AF is $\alpha\delta$,

and $\qquad$ ad is perp. to $\beta\Upsilon$.

Also, the Δ FGH is isosceles, so that

$$\angle HGF = \angle GHF = 90^\circ - \frac{a}{2}, \text{and } GH = 2\,FG \sin\frac{a}{2}.$$

$$\text{Now, } GH = IH - IG = (ID - IE)\sec\frac{a}{2} = (\cos c - \cos b)\sec\frac{a}{2},$$

$$\therefore FG \sin a = 2\,FG \sin\frac{a}{2}\cos\frac{a}{2} = GH\cos\frac{a}{2} = \cos c - \cos b.$$

But FG projects into $I\delta$ equi-sectionally;

$$\therefore I\delta \sin a = \cos c - \cos b \quad . \ . \ . \ . \ . \quad \text{(B)}$$

7. Again,

$$I\delta\,(1 - \cos a) = I\delta \sin a \tan\frac{a}{2} = (\cos c - \cos b)\tan\frac{a}{2}$$
$$= I\beta - I\Upsilon, \text{ by (v) and (vi)}$$

$$\therefore \text{I}\delta\,(1+\cos a) = 2\,\text{I}\delta - \text{I}\delta\,(1-\cos a) = 2\,\text{I}\delta - \text{I}\beta + \text{I}\Upsilon$$
$$= (\text{I}\Upsilon + \text{I}\delta) - (\text{I}\beta - \text{I}\delta)$$
$$= \Upsilon\delta - \delta\beta.$$

$\therefore$ From B, by division, we get

$$(\Upsilon\delta - \delta\beta)\tan\frac{a}{2} = \cos c - \cos b. \quad \ldots\ldots \quad \text{(C)}$$

8. The results (A), (B) and (C) proved above form the basis of the geometrical methods of solution of spherical triangles presented below. In describing the methods, *to avoid confusion, I suppose that the given spherical triangle has not more than one of its given sides greater than a right angle and whenever such a side exists, I take it as the side denoted by a.* It can be easily shown that this supposition does not limit the scope of application of the method. If for instance two of the given sides are each greater than a right angle, we may apply the method to the colunar triangle. *The following considerations also* will be of use in the application of the method.

From (A), $\Upsilon\beta = (\cos b + \cos c)\tan\frac{a}{2} = \Upsilon\text{I} + \text{I}\beta$.

Hence, always supposing $\Upsilon\beta$ as drawn from left to right, we have:—

if $b < 90^\circ$ and $c < 90^\circ$, I lies between β and Υ;
if $b > 90^\circ$ and $c < 90^\circ$, I lies to the left of Υ;
and if $b < 90^\circ$ and $c > 90^\circ$, I lies to the right of β.

Also from (B), $\text{I}\delta \sin a = \cos c - \cos b$.

Hence, $\text{I}\delta$ being supposed positive when δ lies to the right of I, we have:—

if $b < 90^\circ$, $c < 90^\circ$ and $b > c$, δ is to the right of I;
if $b < 90^\circ$, $c < 90^\circ$ and $b < c$, δ is to the left of I;
if $b > 90^\circ$, $c < 90^\circ$ and $b > c$, δ is to the right of I;
and if $b > 90^\circ$, $c > 90^\circ$ and $b < c$, δ is to the left of I;
whence, if δ is to the right of I, $b > c$,
and if δ is to the left of I, $b < c$.

9. In making the constructions to be described, one is supposed to be provided with (besides the ordinary geometrical instruments) a *Quadrant XOY* of a circle of unit radius (= 100 mm. say) drawn on a plane surface ruled with two sets of lines respectively parallel to OX and OY. The arc XY must be graduated in degrees, and the Quadrant should be fitted with a revolving radius, (either a piece of fine thread or a straight metal edge.)

In the diagrams, the following *notation* is used throughout:—

$a,b,c,$	marks on XY corresponding to sides		$a,b,c,$ of $\triangle ABC$;
$g,h,$	do.	do.	$\frac{1}{2}a$ and $\frac{1}{2}b$;

$l,m,n,$	projections of a,b,c on OX;
$a',b',c',$ $a'',b'',c'',$	intersections of the ordinates al,bm,cn with Og and Oh respectively.

Further, we shall denote the *ordinates* of a,b,a',b' etc. by (a), (b) $(a'),(b')$, etc.; so that $(a) = al$, $(a') = a'l$, and so on.

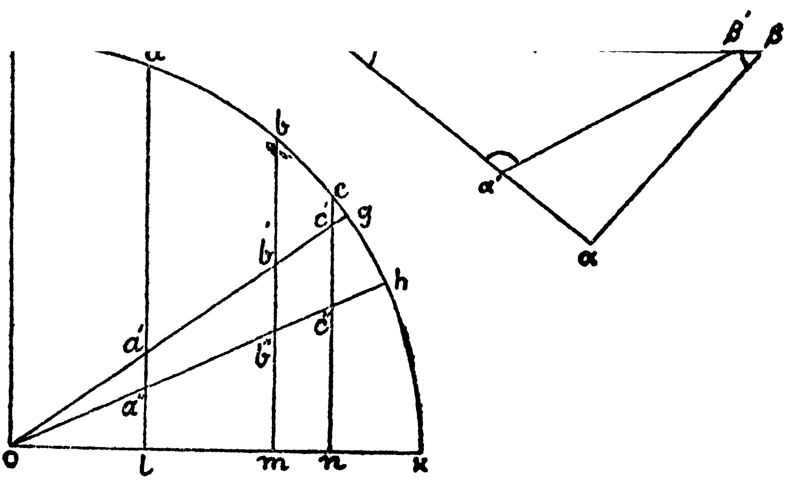
The *use of the Quadrant* is essential in the constructions. It is to be used for three purposes :—

(i) Noting marks on XY corresponding to given angles and vice versa.

(ii) Noting marks on XY corresponding to given projections on OX.

(iii) Noting lengths of ordinates.

10. *Case I.* Given $a,b,c,$ to find A,B,C.



Solution :—Construct $\triangle\ \alpha\beta\Upsilon$, such that

$$\beta\Upsilon = (b') + (c'),\ \Upsilon\alpha = (b),\ \alpha\beta = (c).$$

Also, construct $\triangle\alpha'\beta'\Upsilon$, with α',β' on $\Upsilon\alpha$, $\Upsilon\beta$ respectively, such that $\Upsilon\beta' = (a)$, $\Upsilon\alpha' = (a'') + (c'')$.

Then, $A = \angle\Upsilon\alpha'\beta'$, $B = \angle\alpha\beta\Upsilon$, $C = \angle\beta\Upsilon\alpha$.

Proof:— In the $\triangle\alpha\beta\Upsilon$,

$$\beta\Upsilon = (b') + (c') = (\cos b + \cos c)\tan\frac{a}{2},$$

$$\Upsilon\alpha = (b) = \sin b, \text{ and } \alpha\beta = (c) = \sin c.$$

$\therefore$ By (A), $B = \angle\alpha\beta\Upsilon$, $C = \angle\beta\Upsilon\alpha$.

Also, in the $\triangle\ \alpha'\beta'\Upsilon$,

$$\Upsilon\alpha' = (a'') + (c'') = (\cos a + \cos o)\tan\frac{b}{2},$$

$$\Upsilon\beta' = (a) = \sin a, \text{ and } \angle\beta\Upsilon\alpha = C.$$

$\therefore$ By a relation similar to (A), $A = \angle\Upsilon\alpha'\beta'$.

[In the *diagram*, we have :—

Given, $a = 70^\circ\ 15'$, $b = 49^\circ\ 30'$, $c = 38^\circ 45'$,

we find, $A = 110^\circ\ 45'$, $B = 49^\circ$, $c = 38^\circ\ 30'$].

Case II. Given A,B,C ; to find a,b,c.

Solution :—Solve, as in Case I, the polar $\triangle$ of ABC.

11. *Case III.* Given a,b, C ; to find A,B, c.

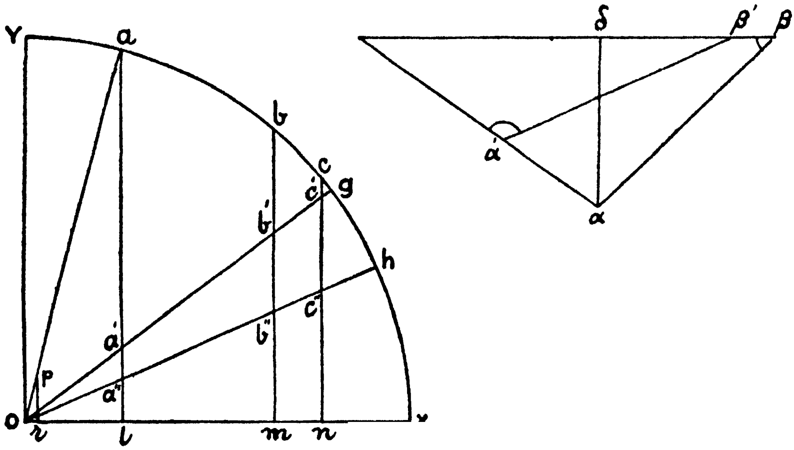


FIG. 4.

Solution :—Construct $\triangle \alpha \Upsilon \mathrm{I}$, such that

$$\angle \alpha \Upsilon \mathrm{I} = C, \quad \Upsilon \mathrm{I} = (b'), \quad \Upsilon \alpha = (b).$$

Draw $\alpha\delta$ perp. to $\Upsilon\mathrm{I}$ produced if necessary. On Oa in the Quadrant, make $Op = \mathrm{I}\delta$, and on OX mark off $mn = (p)$ to the right or left of m according as δ is to the right or left of I. Then, if nc is the ordinate at n to the *arc* XY.

c = the angle given by the graduation mark c.

Now, construct $\triangle$s $\alpha\beta\Upsilon$ and $\alpha'\beta'\Upsilon$, by taking

$$\mathrm{I}\beta = (c'), \quad \Upsilon\beta' = (a), \quad \Upsilon\alpha' = (a'') + (c'').$$

Then, $\quad A = \angle \Upsilon\alpha'\beta', \quad B = \angle \alpha\beta\Upsilon.$

Proof :— $On = Om + mn = Om + (p)$

$$= \cos b + \mathrm{I}\delta \sin a$$

Hence, $\cos c = On$, which gives c.

Rest of the proof is the same as in Case I.

[In the diagram, we have,

Given $a = 76^\circ\ 30'$, $b = 50^\circ\ 15'$, $C = 34^\circ\ 15'$;

we find $A = 121^\circ\ 30'$, $B = 42^\circ$, $c = 40^\circ$.]

Case IV. Given A,B, c ; to find a,b,C

Solution :—Solve as in Case III the polar triangle of ABC.

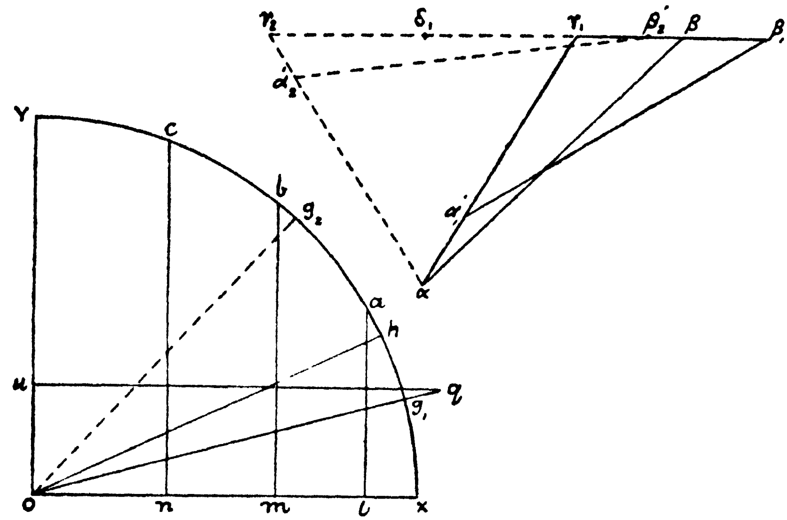


FIG. 5.

12. *Case V.* Given b, c, B; to find A, C, a; $(c > b)$.

Solution :—Construct $\triangle\ \alpha\ \beta\Upsilon$, such that

$\angle\ \beta = \angle\ \mathrm{B}$, $\alpha\beta = (c)$, $\alpha\Upsilon = (b)$; (ambiguous case).

Suppose we get two solutions, viz. $\triangle$s $\alpha\beta\Upsilon_1$ and $\alpha\beta\Upsilon_2$.

Note u on OY such that $\mathrm{O}u = nm$, and note p, q on the ordinate at u such that $up = \beta\Upsilon_1$ and $uq = \beta\Upsilon_2$. Note now the points g_2 and g_1 where Op and Oq cut arc XY. Then

$$a_1 = 2 \text{ the } \angle \text{ marked by } g_1 \text{ and } \mathrm{C}_1 = \angle\ \beta\Upsilon_1\alpha.$$

Also, $$a_2 = 2 \text{ the } \angle \text{ marked by } g_2 \text{ and } \mathrm{C}_2 = \angle\ \beta\Upsilon_2\alpha.$$

To find A_1, A_2, now proceed as in case I.

Proof:—If $\alpha\delta$ be perp. to $\beta\Upsilon_1\Upsilon_2$, then by property (C)

$$nm = \cos b - \cos c = (\delta\beta - \Upsilon\delta)\tan\frac{a}{2}.$$

Now $\Upsilon\delta$ is +ve or − ve according as δ lies to the right or left of Υ; also $\delta\Upsilon_1 = \Upsilon_2\delta$.

$$\therefore\ \text{For } \triangle\alpha\beta\Upsilon_1,\ nm = (\delta\beta + \delta\Upsilon_1)\tan\frac{a_1}{2} = \Upsilon_2\beta\tan\frac{a_1}{2}.$$

and $$\text{for } \triangle\ \alpha\beta\Upsilon_2,\ nm = (\delta\beta - \Upsilon_2\delta)\tan\frac{a_2}{2} = \Upsilon_1\beta\tan\frac{a_2}{2}.$$

$$\therefore\ \tan\frac{a_1}{2} = \frac{nm}{\Upsilon_2\beta} = \frac{\mathrm{O}u}{uq} = \tan g_1;\ \tan\frac{a_2}{2} = \frac{nm}{\Upsilon_1\beta} = \frac{\mathrm{O}u}{up} = \tan g_2.$$

Hence the given construction for a_1 and a_2.

[In the diagram we have

Given	$b = 50^\circ\, 45'$,	$c = 69^\circ\, 15'$,	$B = 44^\circ\, 30'$;
we find	$A_1 = 25^\circ\, 45'$,	$C_1 = 122^\circ\, 30'$,	$a_1 = 29^\circ\, 0'$
	$A_2 = 115^\circ\, 30'$,	$C_2 = 57^\circ\, 30'$,	$a_2 = 95^\circ\, 15'$].

Case VI. Given B,C, b; to find a, c, A.

Solution :—Solve as in case V the polar Δ of ABC.

The formulae (A), (B), (C) may be used to derive the usual fundamental formulae of Spherical Trigonometry; also proofs of the geometrical constructions given above may be obtained by using the ordinary formulae, but are somewhat lengthy and unnecessary here.

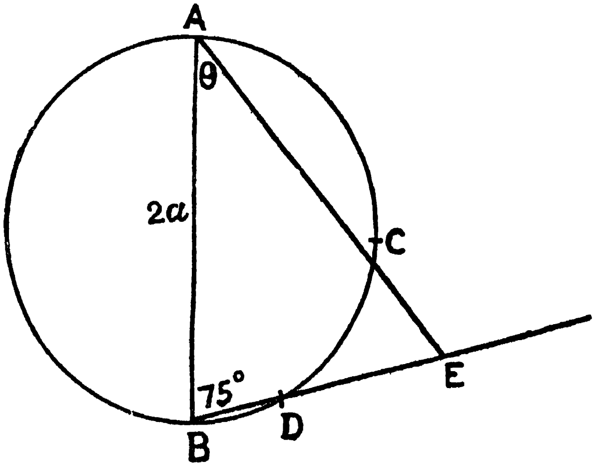
AN APPROXIMATE CONSTRUCTION FOR AN ANGLE OF 40°

By

V. M. TELANG, B. A.

The following very elegant and simple method of approximately constructing an angle of 40° is given by me in the Indian Mathematical Society's Magazine, January, 1933.

Take a circle ABC. AB is the diameter and C the midpoint of *Arc* AB. With centre C and radius = ½ AB cut *arc* CB at D. Join



BD and measure BE = BC. Then the angle BAE = approx. 40°.

For let AB = $2a$, then BC = $a\sqrt{2}$ and the angle ABD = 75°. Hence if $\angle$ BAE = θ.

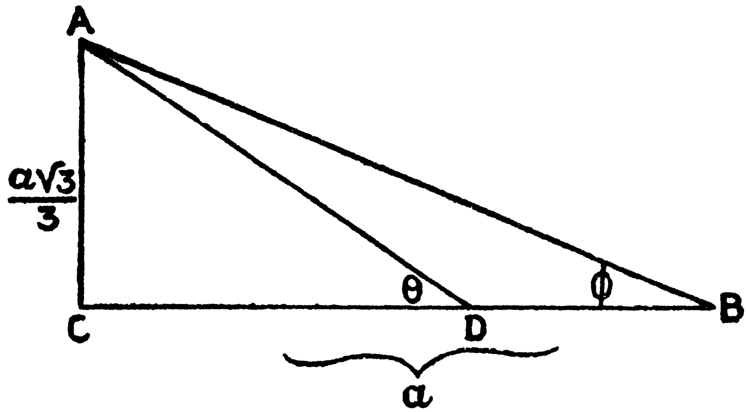
$$\frac{\sin\theta}{a\sqrt{2}} = \frac{\sin(75^\circ + \theta)}{2a}$$

This gives $\theta = 39^\circ\ 24'$ approximately.

This construction amounts practically, to the construction of a $\triangle$ of sides $2a$, $a\sqrt{2}$ and the included angle 75°.

Another construction to a better approximation may be given as follows.

Take a triangle ABC *rt.* $\angle$ *ld* at C with sides a and $\frac{a\sqrt{3}}{3}$.



BC = a. Measure CD = $\frac{17}{25}$ of a. This means divide CB into 25 parts and take 17 parts upto D. Then the angle $\phi = \tan^{-1}\left(\frac{a\sqrt{3}}{3} \,/\, a\right) = 30^{\circ}$ and the angle $\theta = \tan^{-1}\left(\frac{a\sqrt{3}}{3} \,/\, \frac{17a}{25}\right)$ $= 40^{\circ}$ approximately.

This construction is better as it gives the result correct to within two decimal places. This latter construction is not also inconvenient from a practical standpoint if 25 divisions of a scale are used as the starting length.

NEW LIGHT ABOUT AN ANCIENT INDIAN ASTRONOMER'S FIRST POINT OF THE ECLIPTIC

By

A. E. PALKAR

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(*Synopsis*:—For the last hundred years or more, the Western scholars are of the opinion that the Indian astronomers calculated the places of the planets, the sun and the moon from zeta-Piscium. Amongst the Indian astronomers of the present generation, there is a sharp controversy over this point. In this thesis, it is definitely shown by means of *new circumstantial evidence* that one of the ancient astronomers namely Ganesh Daivadna did not hold ζ Piscium as the first point of the ecliptic. Also it is proved incidentally that alpha-Orionis is the principal star of Ardra).

Mr. John Bentley, a member of the Asiatic Society published in 1823, a treatise entitled "Historical View of the Hindu Astronomy". In this book he had advocated many of his theories; one of these being that ζ Piscium is the starting point of the ecliptic according to ancient Hindu astronomers. Since his days, there has been a sharp controversy amongst the Indian astronomers about their starting point of the ecliptic.

There is one important difference between the Western and Hindu astronomers about the method of calculating the longitude of a celestial body. The Western astronomers calculate the longitude of a heavenly body from the cutting point of the equator and the ecliptic. But the Hindu astronomers have been in the habit of calculating the longitude of a celestial body from some fixed point. A few centuries after the Christian era, this method of determining the longitude of a body from some fixed point came into vogue in India. The exact date, when this method was first used by the Hindu astronomers is not known. It is supposed that in 444 of the Shaka era (*i.e.*, in 522 A.D.) the cutting point of the ecliptic and the equator (*i.e.*, vernal equinox) and the Hindu astronomers' starting point on the longitude circle coincided. But no definite opinion can be expressed about this date. I have determined the view of Ganesh Daivadna who wrote his famous treatise "Grahalaghava" in 1520 A. D. This book is so widely used and studied by the Hindu astronomers that the more ancient treatises of the Hindu astronomers such as Aryabhata Brahmagupta, Lalla & etc, have been superseded on the major portion of the

Hindu continent. One of the striking features of this book namely Grahalaghava as compared with the more ancient books on the same subject is that the places of the planets, the sun and the moon can be calculated without the use of trigonometrical functions. In order to understand the usefulness of Grahalaghava to ancient Hindu astronomers one must pay attention to the following two handicaps to which they were subject: (*i*) In those days the Hindus had the tables of the sine of angles differing by $3\frac{3}{4}$ degrees, and (*ii*) all multiplications and divisions had to be done without the use of the logarithmic tables. The calculating machines of the present generation would have been to them a veritable Aladdin's lamp!! Hence it was very tedious and troublesome to them to calculate the places of the planets etc., by means of the methods advocated by the still more ancient Hindu astronomers such as Aryabhata, Brahmagupta etc.

It is definitely known that Keshava Daivadna, the father of Ganesh Daivadna was also a great Hindu astronomer and that his son Ganesh Daivadna had studied astronomy under his father's tutorage and that both the father and the son had taken numerous observations of the stars and planets. After taking into consideration all these facts, we can safely draw the inference that Ganesh Daivadna must have definitely fixed upon the starting point of the ecliptic for his Grahalaghava. If it can be ascertained that his starting point was not ζ Piscium, *some definite insight* about the opinion held by the Hindu astronomers of his period will be available to us.

Now one outstanding feature of the ancient Hindu astronomers is that they did not, as a rule, give the observations and the exact date of those observations. If they had given the exact date and the observations taken by them, it would have been very useful to later generations. Though the ancient Hindu astronomers did not give their observations with the dates, they introduced many "Bija-sanskars" or corrections into the current methods of their times. But these corrections cannot, as a rule, be used in deciding the debatable point of ζ Piscium. As neither the observations nor the corresponding exact dates are known, it is not possible to guess anything with certainty.

I have come across a certain passage of Ganesha Daivadna occurring in Muhurta Sindhu:—

प्राग्लभस्य लवाः खमध्यगते दास्रे द्विदिग्भिर्मिता
याम्येसूर्यभुवोग्निभेऽष्टमिहिरा ब्राम्हे खशक्रोन्मिताः ।
चांद्रेत्र्यक्षभुवोभवेंऽगतियस्त्र्यष्टेंदवः सप्तमे
पुष्येंऽगांकभुवोऽहिभेऽद्रिगविलाः पित्र्येऽद्रिभूबाहवाः ॥ १ ॥

भाग्ये दंतदृशोऽर्यमोडुनि नभःसिद्धाः करे कक्षदृक्
त्वाष्ट्रे त्र्यंगदृशोऽनिलेऽद्व्यगदृशो द्वीशे कुनंदाश्विनः ।

मित्रेऽक्षाभ्रगुणाः परे रविगुणा मूलेऽद्रिदंता जले
पंचाब्ध्यभ्रय उत्तरे क्षिषुगुणा ब्राम्हेऽब्धिबाणाभ्रयः ॥ २ ॥
श्रीपेऽर्का वसुभे गजाश्विन इहांब्वीशोडुनीलर्तवोऽ
जांघ्रौ षट्षडुपांतिमेऽब्धि तुरगाः पौष्णेऽब्धिनंदा इमे ।
प्रोक्ताः केशवदैववित्तनुभुवा श्रीमद्गणेशेन वै
यद्देशे पलभा युगांगुलमिताऽन्यत्रत्विमेऽल्पान्तराः ॥ ३ ॥

Translation:—"When the nakshatra Aswini comes on the meridian, the rising point of the ecliptic is 102°; in the case of the nakshatra Bharani it is 112°; that in the case of the nakshatra Kritika it is 120°; that of Rohini 140°; that of Mrigashirsha 153°; that of Ardra 156°; that of Punarvasu 183°; that of Pushya 196°; that of Ashlesha 197°; that of Magha 217°; that of Purvafalguni 232°; that of Uttaraphalguni 240°; that of Hasta 251°; that of Chitra 263°; that of Swati 277°: that of Vishakha 291°; that of Anuradha 305°; that of Jeshta 312°; that of Mula 327°; that of Purvashadha 345°; that of Uttarashadha 351°; that of Abhijit 354°; that of Shravan 12°; that of Dhanista 28°; that of Shatataraka 61°; that of Purva Bhadrapada 66°; that of Uttara Bhadrapada 74°; and of Revati 94°;. This is stated by Ganesh the son of Keshava Daivadna; and these figures will be true in the case of a place having four "Palabha" (*i.e.*, having the latitude of $18^{\circ}\ 26'$); but at other places, there will be small differences." Now the date of this author's widely known and circulated book of Grahalaghava is 1442 of the Shaka era (*i. e.*, 1520 A. D.) and he must have made the above mentioned observations prior to this period. Now as these are the observations about fixed stars and not about the planets, even a difference of some 20 years would not amount to even 1/3 of a degree due to the precession of the equinox. The ascending point of the ecliptic is to be observed on the eastern horizon at a place having four palabha *i. e.*, a place having the latitude of $18^{\circ}\ 26'\ 6''$. Nandigram or Nandagaum, the native place of Ganesh Daivadna has the latitude of nearly $18^{\circ}\ 26'$, and so we are certain that he obtained the figures mentioned in the verses by actual observations.

Out of the 28 stars, mentioned in his verses, *only those* can be relied upon which were near the celestial equator. The necessity of this condition can be explained thus: a star which has much declination towards the north will appear to stay for a longer period on the meridian "belt" and a star having much southernly declination will appear to move rapidly on the meridian "belt". Secondly the point of the ecliptic which will be ascending when a particular star is on the meridian should not make a very large angle OE*; otherwise the points on the ecliptic will not be rising with the same speed (*i. e.* angular

* The angle of the rising point of the ecliptic with the East-West line.

motion per unit of time) as the star on the meridian. By meridian "belt", I mean a small strip of the sky made up by two parallel circles at a very small distance (say $\frac{1}{8}$ degree) on either side of the meridian. The stars will appear to be on the meridian circle to an observer with rudimentary instruments when they are within the meridian "belt".

Hence these two conditions are absolutely necessary if we have to use the data given by Ganesh Daivadna with confidence.

It is certain that he must have taken his observations either with primitive instruments such as Ghatika (Indian water clock), Nalika-yantra (the Indian astrolabe) etc. or by simple observations. For it is known that the chronometer or the telescope or other modern instruments which can give very accurate results were unknown to Indian astronomers of those days. The Indian astronomers drew their conclusions about the apparent motion of the planets etc. by taking a large number of observations with simple instruments, for a long period.

Now when the criteria–namely the star on the meridian as well as the rising point of the ecliptic should be very near the equator–be applied to the 28 stars quoted in the above mentioned verses, two only can be selected out of the 28 stars and the rest must he refused. These two are Ardra and Shravan.

But about the principal star of Ardra there is some difference of opinion. Mr. John Bently and Raobahadur Chhatre were of the opinion that the principal star of the Indian lunar mansion Ardra is 133 Tauri. But authorities like Colebrooke, Whitney, Burgess, Bapudeo and Ketkar are of the opinion that Alpha Orionis is the star of Ardra, while Dikshit alone held the view that Gamma Geminorum is the principal star. No reliable inference can be drawn unless this difference of opinion be settled with certainty. So I shall examine the opinions of these persons.

Now these different opinions arose because Bentley, Chhatre and Dikshit supposed that α Orionis is a star comprising the lunar mansion (nakshatra) Mriga (deer). But if we take into consideration that the proper names of that lunar mansion is Mrigasheersha (head of the deer) and not Mriga (deer) alone, then there can be no difficulty in assigning α Orionis as the star of Ardra. Bentley and Chhatre took 133 Tauri as the principal star of Ardra which is much removed towards the north of Orionis. But Dikshit could not acquiesce himself with 133 Tauri which is of 5·2 magnitude. Hence he chose γ Geminorum which has the magnitude of 1·9.

Again it should be noted that those lunar mansions (nakshatra) which are constituted by a single star cannot have a star like 133 Tauri, the magnitude of which is 5·2, *e. g.* (*i*) The nakshatra Chitra is composed of one star namely the Spica and the Spica is of 1·2 magnitude.

(*ii*) The nakshatra Swati is made up of one star namely the Arcturus & the Arcturus is of 0·2 magnitude. Therefore, the only star of Ardra cannot be 133 Tauri the magnitude of which is 5·2. It may be noted, in addition, that stars of the 5th and 6th magnitude are only visible when the sky is quite clear and also when the bright moon is not in their vicinity. Again it is worth noting that Bentley expressed with great diffidence his view that 133 Tauri is the star of Ardra. For on page 104 of "Historical View of the Hindu Astronomy" he placed the sign of interrogation after 133 Tauri. So when it is known that Bentley himself is not confident about 133 Tauri and that scholars like Colebrooke, Whitney, Burgess, Bapudeo and Ketkar are of the opinion that α Orionis is the star of Ardra, we can very safely set aside 133 Tauri. The opinion of Dikshit will be scrutinised at the end of this essay and it will be proved there that he was quite wrong in assuming Υ Geminorum as the star of Ardra.

It is also worth noting that all the ancient Indian astronomical works such as Nakshatra Kalpa, Vridhagargiya-sanhita, Varaha-mihir, Khanda-Khanyaka, Ratna-kosha of Lalla, Shakalyabrahma-sidhanta, Ratnamala of Shripati, Muhurta-mala, Muhurtachitamani, etc., unanimously say that the lunar mansion of Ardra has only one star. Also the following verse known under the name of Mulanusari-sphuta says that the lunar mansion of Ardra is like mani (jewel)

त्रिभिर्मृगास्यं मणिरूपमेकं हर्म्यं चतुर्भिस्त्रितयेन बाणः ।

(Meaning :—Mrigashirsha has three stars of the form of the mouth of a deer, Ardra has one star like mani i.e. jewel, Punarvasu has four stars like a house, Pushya has three stars like an arrow.) So α Orionis which is of ·3 to 1·1 magnitude must be the only star of Ardra to sparkle like a jewel and the star 133 Tauri which is of 5·2 magnitude can never possibly be the star of Ardra.

Now let us find out by calculations the rising point of the ecliptic at the time of Ganesh Daivadna when α Orionis used to come on the meridian at a place, the latitude of which is $18^\circ\ 26'$. On the 1st of January 1920, the R. A. of α Orionis is $87^\circ\ 42'\ 49''$ and the declination is North $7^\circ\ 23'\ 33''$. The obliquity of the ecliptic is $23^\circ\ 26'\ 54''$. By changing these co-ordinates, we get :—

$$\text{Longitude} = 88^\circ\ 59'\ 51'' \ \&$$
$$\text{Latitude} = 16^\circ\ 1'\ 58'' \text{ South.}$$

Also in 400 years the precession of the equinox—

$$= 50{\cdot}26'' \times 400$$
$$= 5^\circ\ 35'\ 4''$$

Therefore in the days of Ganesh Daivanya, the longitude of α Orionis is got by deducting $5^\circ\ 35'\ 4''$ thus

$$\begin{array}{rrr} 88^\circ & 59' & 51'' \\ 5^\circ & 35' & 4'' \\ \hline 83^\circ & 24' & 47'' \end{array} = \text{long. of } \alpha \text{ Orionis.}$$

But the latitude of a star remains the same.

The corresponding R. A. for α Orionis having the longitude of

$83^\circ\ 24'\ 47''$ and the latitude of
$16^\circ\ 1'\ 58''$ is $82^\circ\ 18'\ 3''$.

Now 400 years ago when the star α Orionis having the R. A. of $82^\circ\ 18'\ 3''$ came on the meridian, the point of the ecliptic on the eastern horizon will be $172^\circ\ 40'\ 6''$ and the angle OE (i. e. the angle made by this point with the East-west line will be only $3^\circ\ 2'\ 8''$).

Now it may be noted that Ganesh Daivadna did not know the correction for the refraction. Therefore this correction must be added: So

$$\begin{array}{rr} 172^\circ & 40' \\ 0^\circ & 33' \\ \hline 173^\circ & 13' \end{array}$$

Therefore $173^\circ\ 13'$ will be the apparent ascending point of the ecliptic on the eastern horizon.

It must be specially noticed that, I have followed this tedious process of twice changing the co-ordinates and then finding out the rising point of the ecliptic instead of using the easy method of the the annual variation. For a period of 400 years, the figures for annual variation are not reliable and hence these cannot be used in the present case.

Now it will be seen that the apparent rising point of the ecliptic is $178\frac{1}{4}$ during the days of Ganesh Daivadna. But in the verses quoted from "Muhurtasindhu," it is said that the rising point of the ecliptic is 156° when α Orionis comes on the meridian. Therefore deducting 156° from $173\frac{1}{4}$ we get $17\frac{1}{4}^\circ$. This must be *approximately* the distance according to Ganesh Daivadna between the true vernal equinox of those days and the Hindu astronomers' starting point of the ecliptic. But in those days ζ Piscium was at a distance of $13\frac{1}{4}$ from the vernal equinox.

I have already noted that Ganesh Daivadna and Keshava Daivadna his renowned father and preceptor in astronomy had made that science their lifelong study and occupation. It may be noted also that Ganesh Daivadna's views were accepted by his ***immediately succeeding generations***. Thus his treatise superseded the works of ancient authors for calculating the places of the planets, the sun and the moon. Hence it is settled that Ganesh Daivadna who had taken actual observations was of the opinion that the Hindu astronomers'

starting point on the ecliptic is some point other than ζ Piscium and that this point is at a distance of about 17° from the vernal equinox.

I shall give another *corroborative evidence.*

In the case of the lunar mansion Shravana, it is unanimously admitted that α Aquilae is the principal star. The R. A. of α Aquilae or Altair is $296^{\circ}\ 42'\ 42''$ on the 1st of January 1920 and the declination is North $8^{\circ}\ 39'\ 22''$. The obliquity of the ecliptic is $23^{\circ}\ 26'\ 54''$. By changing these co-ordinates, we get $300^{\circ}\ 38'\ 52''$ as the longitude of α Aquilae and the latitude of it is $29^{\circ}\ 14'\ 28''$ North. The precession of the vernal equinox in 400 years is $5^{\circ}\ 35'\ 4''$. Therefore the longitude of α Aquilae must be $295^{\circ}\ 3'\ 48''$ in the days of Ganesh Daivadna. The latitude remains the same. Now by again changing the co-ordinates we get the R. A. of α Aquilae to be $291^{\circ}\ 52'\ 35''$. This was the R.A. of α Aquilae in the days of Ganesh Daivadna. When this star came on the meridian at a place having the latitude of $18^{\circ}\ 26'$, the ascending point of the ecliptic on the eastern horizon was $27^{\circ}\ 27'\ 18''$ and the angle OE was $11^{\circ}\ 9'\ 49''$; and by adding $33'$, the correction of refraction, we get $28^{\circ}\ 0'$. But Ganesh Daivadna says that the rising point of the ecliptic is 12°. Hence the distance of the vernal equinox from the Indian astronomers' starting point on the ecliptic was $16^{\circ}\ 0'$ in the days of Ganesh Daivadna.

In the case of the lunar mansion Ardra, this distance was found to be $17\frac{1}{4}$ so there is a difference of $1\frac{1}{4}$ degrees. But this difference can very easily be accounted for. Firstly the angle OE in the case of Shravan (*i.e.*, α Aquilae) is 11° which is rather large and in the case of Ardra (*i.e.*, α Orionis) this angle is 3° only. Secondly Ganesh Daivadna had to take his observations with the help of rudimentary instruments. Therefore it is but natural that small discrepancy is very likely to arise in noting the ascending point of the ecliptic which makes such a large angle OE of 11°. However it is not at all necessary to enter into minute details whether $17\frac{1}{4}$ or 16 is the more correct value. Even with either of the value namely 16 or $17\frac{1}{4}$, it proves that Ganesh Daivadna and his contemporaries did not think that ζ Piscium was the starting point of the ecliptic.

Finally the case of γ Geminorum advocated by Dikshit will be considered.

This star may be similarly treated as was done in the case of α Orionis and α Aquilae and the rising point of the ecliptic, may be found out when γ Geminorum came on the meridian in the days of Ganesh Daivadna. It will be found after the calculations that the rising point of the ecliptic was $182\frac{1}{2}$. This value is *inconceivably* wrong with the circumstance of the case. Because if γ Geminorum be accepted, then in the days of Ganesh Daivadna, the distance between the Hindu astronomers' starting point and the vernal equinox of those

days amounts to 26½. This absurd result cannot be got by rudimentary instruments or by even bare observations of the eye alone !! And hence γ Geminorum cannot possibly be the star of Ardra. Dikshit was led to think that α Orionis cannot be the star of Ardra, because it is part of Mriga (deer) and hence some other star of first or second magnitude near about α Orionis should be the star of Ardra. But as already pointed out Mrigasheersha (head of the deer) and not Mriga (deer) is the proper designation of the lunar mansion preceding Ardra.

Conclusion :—

This method which is based upon the actual observations of Ganesh Daivadna, does not require the *exact date* of the observations obtained by him. A difference of even 25 years will produce at the most a change of 1/3 degree. Also the observations are free from any prejudice as there was no bitter controversy in his days about the starting point of the ecliptic. He must have adopted the view as was then prevalent throughout the major Hindu continent, with some minor changes of his own. Also these observations are of the nature of *circumstantial evidence*. Hence they are important in giving an insight about the opinion of Ganesh Daivadna and his contemporary astronomers about their starting point of the ecliptic. They held *impliedly* that ζ Piscium is not the starting point of the ecliptic and that this point was at distance of about $16\frac{3}{4} \pm \frac{1}{2}$ degrees from the vernal equinox of their days. The quantity $\frac{1}{2}$ degrees is introduced from the fact that the correction for refraction was never detected by the ancient astronomers ; therefore I have taken $\frac{1}{2}$ degree as the value of " probable error ".

DIETETICS: FOOD AND RACE

By

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We are living in the twentieth century, a century in which science has made a most extraordinary progress in all directions. Of all the investigations made during the last 20 or 30 years those made in the science of dietetics will hold a no mean place, for they have a vital bearing on the improvement of the human race. The conclusions to which Major-General Sir McCarrison and other workers in the same field have come as a result of their investigations on food, have been most far-reaching and have given a new hope to man. He is now no longer helpless as before when he was under the false notion that climate was the principal factor in influencing the health and growth of the body. McCarrison has conclusively proved that it is not so much the climate as food which plays a vital part in producing a strong healthy man or a weakling suffering from all sorts of ailments. Climate one cannot control but food one can and therefore it is that a new world of hope and cheer has opened out before man inasmuch as it is completely within his power to maintain good health and efficiency and improve his race by taking advantage of the latest researches on dietetics.

If science has shown what a powerful weapon the knowledge about food is in the hands of man for making the race healthy, strong, physically fit and efficient what steps should be taken to bring about this result in a country like ours where an epidemic like influenza can sweep off, at one fell swoop, more people in one year than the great war had done in four years, showing how low the vitality of the people and their resisting power against disease must be. An important advance would be made if well-balanced dietaries catering to all tastes and suitable to all purses were prepared. India is a poor country and therefore the dietaries must be very cheap. It is, therefore, very necessary to make investigations to find out cheap but at the same time nutritious substitutes of food materials to replace the costly ones. India is, again, a country so vast and varied in respect of climate, altitude and soil that it is in a position to produce successfully every variety of grain, millet, bean and other food materials. Every effort must, therefore, be made to grow in our country food-stuffs of our own and other countries which have been

found by experiment and experience to satisfy the physical, chemical-bio-chemical, physiological and economical tests *e.g.*, soya bean, (vide page 253).

This naturally brings into prominence the importance of establishing Institutes of Nutritional Research in every Province in a big country like India and directs our attention to the intimate connection they should have between the Agricultural Departments on the one hand and the Industrial Centres on the other. To the former they would suggest problems of research such as that of studying the best conditions under which a food-stuff like Soya bean can be grown in our country and to the latter they would suggest the need of doing propaganda work among the industrial population for a large use of certain food-stuffs which have been found to be best and of making an adequate provision for their supply at a very cheap rate and in an unadulterated form. They would also be helpful in preparing the dietaries mentioned above.

It is to the important investigations on food-stuffs carried out by F. Gowland Hopkins in England, by Osborne and Mendel, McCollum and Davis in America and by E. Abderhalden in Germany that we owe our present knowledge of the new values of nutrition and the new standpoints in the study of nutrition. It is to the investigations of these men and particularly to the researches carried out by McCarrison in India on the Indian food-stuffs and their bearings on health and disease and physical efficiency that I shall refer, now and again, in the course of this article, to show how they vitally affect the question of the improvement of the human race.

Major-General Sir McCarrison, Director of Nutritional Research at the Pasteur Institute, Coonoor, South India, in the evidence he gave before the Royal Labour Commission three years ago made the following memorable statement on the relation of food to the physical efficiency of Indian workers: " ' The level of physical efficiency of Indian workers is, above all else, a matter of food. No other single factor, race, climate etc. has so profound an influence on their capacity to sustain arduous labour and prolonged muscular exertion. Nowhere in the world is this outstanding influence of food more conspicuously illustrated than in India. As we pass from the North-west regions of the Punjab down the Gangetic Plain to the coast of Bengal, there is a gradual fall in the stature, body-weight, stamina and efficiency of the people. In accordance with this decline in manly characteristics it is of utmost significance that there is an accompanying gradual fall in nutritive value of the dietaries, and more especially in the average level of protein metabolism attained by the people of the Punjab, United Provinces, Behar and Bengal.' Lt. Col.D.McCay of the Indian Medical Service reached these conclusions

some 20 years ago as a result of his nutritional researches; my investigations have served to confirm their accuracy. This decline in physical efficiency extends also to inhabitants of the Southern and Western parts of the Indian Peninsula. It depends almost entirely on the gradually diminishing value of the food with respect to:

A. The amount and quality of its proteins.

B. The quality of the cereal grains forming the staple article of the diet.

C. The content and the quality of the fats in food.

D. The vitamin and the mineral content of the food."

The same idea gains further support by the evidence adduced to solve the following questions: Is it because of the preponderating race diet that the Japanese, the Chinese, the Javanese and other oriental races are short in stature? Again, is it because the Polynesians, the Northern Europeans, the Sikhs, the Punjabis and the Pathans hit upon a dietary conducive to greater growth that they are taller in stature? Let us examine the evidence on the subject.

It was found by Japanese Scientists that by changing the dietaries of certain school-going children the children who received a diet augmented by food used by the taller races were found to be several inches taller and several pounds weightier than the children who were fed on the normal diet of the country.

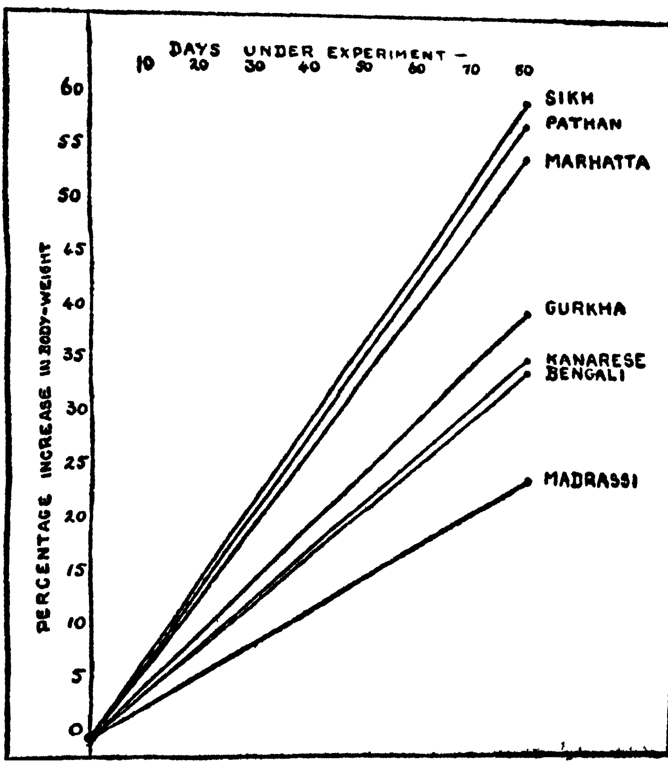
There is a German proverb which says 'Man ist was er isst' (a man is what he eats). This view was further confirmed by experiments carried out on rats. The rat is an excellent animal for purposes of these experiments. They are both vegetarians and carnivorians and as their metabolic processes resemble those in man the effects of food upon rats are often analoguous to those upon men. Again, the young of these animals grow and breed rapidly and medical scientists are therefore able to observe the changes taking place in their organisms within a few days or weeks at the most and consequently to draw accurate conclusions from experiments carried out on them under experimental conditions.

In the discussion of the question on the relationship between climate, food and soil on the one hand and physical efficiency, health, resisting power against disease, capacity for endurance and hard work etc., on the other it was difficult to decide which of the three factors climate, food or soil played the most important part. This question was very ingeniously solved by McCarrison by selecting Coonoor, a beautiful spot on the Nilgiri Hills, 6000 feet above the sea level, reputed for its salubrious climate, as the station for his classical experiments and by the strictly scientific conditions under which he carried them out. He had the following factors constant for all his experiments, viz. climate

and soil; the only factor which he varied was food. McCarrison as a result of the experiments made under the above-mentioned conditions was able to come to some most important and far-reaching conclusions as to the effect of food upon the health, stature, stamina, physical efficiency, etc. of the rats; for food was the only factor which he varied, keeping all other factors constant throughout the experiments. He did not arrive at these conclusions by making one or two experiments but a large number extending over a period of three years over hundreds of rats all of which pointed to the same conclusion.

RELATIVE VALUES OF THE NATIONAL DIETS OF INDIA.

DIAGRAM 1*



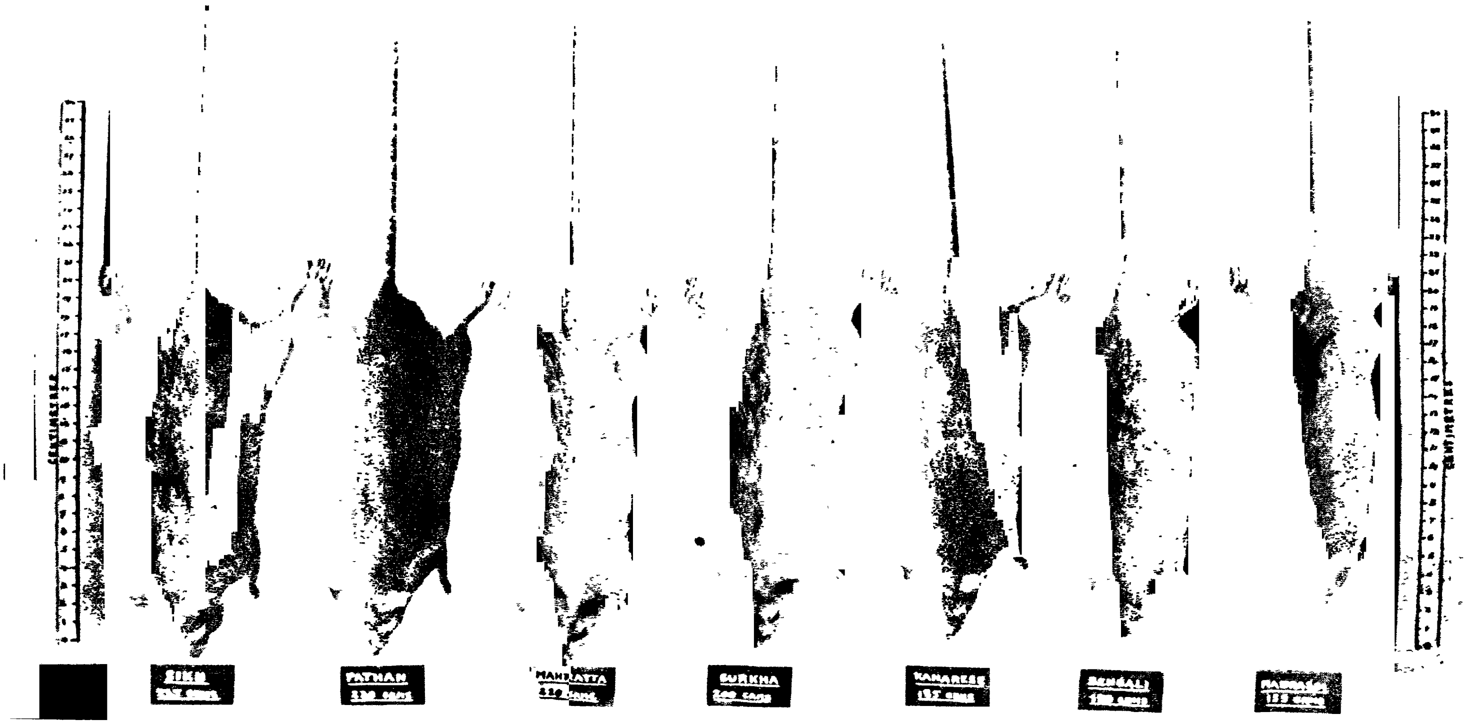
Graph to show growth in the weight of rats during the experiments in feeding on the diets of different races.

In one of the classical experiments devised by McCarrison to find out the nutritional values of the diets of different Indian races he fed rats on the dietaries of the following races, viz. Sikhs, Gurkhas, Marathas, Pathans, Kanarese, Bengalis and Madrasis and found that

* By Courtesy of Major-General Sir McCarrison.

AVERAGE SPECIMENS OF COLONIES OF RATS FED ON THE NATIONAL DIETS OF INDIA

DIAGRAM 2*



SIKH PATHAN MAHRATTA GURKHA KANARESE BENGALI MADRASSI

* By kind permission of Major General Sir Rober McCarrison

the percentage increase in body weight of rats fed on the Sikh diet after 80 days was the highest (60) while that for the Madrassi diet for the same period was found to be the lowest (18). Diagrams 1 and 2. give a vivid picture of the effect of food on the growth and size of the body. The Sikh and Madrassi diets which were given to the rats in these experiments are shown in Appendix A.

The conclusions regarding the relative physical efficiency of the different Indian races arrived at by McCay and McCarrison have been independently confirmed by Prof. Vaidyanathan from the investigations made by him on the height, weight, chest and abdominal measurements of 51,186 Lives of Hindus from different provinces of India Assured with the 'Oriental Life Office.' He states in his report[1] "There is no questioning the fact that the Punjabi is the best of all Indian types when the comparison is based upon weight given height and age." The second place is given by him to the Hindus of the United and Central Provinces and Bengal. As regards the two remaining groups of Hindus, *viz.* the Madras Hindu and the Bombay Hindu he states "There is no question but that these two classes carry the tail end of the whole Hindu Group."

In the second experiment devised with the same object McCarrison fed rats on the habitual diet of the poorer classes in Europe and compared it with that of the Sikhs. The results of the experiments were that the rats of the Sikh group were of much larger size with smooth coats and gentle demeanour while those of the European group were stunted in growth, had rough coats, a nervous disposition and suffered severely from diseases of various kinds. These experiments show that change in national diets may change national characteristics in the future; they also show the relative nutritional values of the national diets of different races.

In the other experiments devised by McCarrison to find out the relationship between food and health on the one hand and food and disease on the other, he observed the following conditions *viz.*, he used the same animal houses, the same cages, the same scrupulous cleanliness, the same duration of exposure to the sun's rays and under the same salubrious climate of Coonoor. In one series of experiments he took a community of rats and fed them on a well-balanced diet— "a diet similar to that eaten by certain races of Northern India, among whom are to be found some of the finest physical specimens of mankind".[2] What was the result? During the period of experi-

1. Report on an 'Investigation into the Height, Weight, Chest and Abdominal Measurements' of Lives Assured with the 'Oriental Life Office' between the years 1914 to 1924 by L. S. Vaidyanathan, M.A., F.I.A., Deputy Actuary of the 'Oriental Life Office' and Professor of Acturial Science, the Sydenham College of Commerce and Economics, Bombay.

2. From an article by McCarrison on "Food: The Foundation of Health."

mentation which extended over a period of three years there had been "no case of illness among these rats, no deaths from natural causes in the adult stock, and but for a few accidental deaths, no infantile mortality . . . . Both clinically and at postmortem examinations they have been shown to be remarkably free from disease. Disease and death have been excluded almost completely by minute attention to three environmental conditions *viz.*, cleanliness, comfort and food".[1] In the other series of experiments he took different groups of rats and fed them on different kinds of diets which were ill-balanced, or in other words, were deficient or preponderating in one or more important constituents of food, faulty in one way or another, containing too much of one thing or too little of another. As McCarrison wanted to learn how the foods eaten by the people of India are related to disease he took care to see that the materials of food which formed the various faulty dietaries given to rats under experimentation were usually those ordinarily used by the people of India. These were so combined as to form one-sided dietaries disproportionately rich in starches and carbohydrates and lacking in certain elements and complexes necessary for normal nutrition. The results of these experiments were remarkable. Whereas the well-fed rats remained free from disease, the ill-fed rats showed the following morbid states both clinically and at postmortem examinations: "Pneumonia and other diseases of the lungs; diseases of the nose and the passages leading from it; diseases of the ear causing pus formation, adenoids, diseases of the eye which may lead to actual blindness; diseases of the stomach and the intestines such as inflammation of the bowels and ulcers; stone in the bladder and kidney and inflammation of the bladder; premature birth of the young or their death in the mother's womb; diseases of the skin such as loss of hair dermatitis and abscesses; anæmia; dropsy; enlarged glands; goitre; neuritis; beri-beri; disease of the heart. And when other animals, such as guinea-pigs, are improperly fed scurvy, decaying teeth, rickets or softening of the bones, colitis, dysentery and other diseases occur amongst them".[2] This shows that mankind in general suffers from one major disease—*Malnutrition*—and that many of the maladies from which it suffers arise principally from this cause.

McCarrison found also some other peculiarities in which the ill-fed rats differed from the well-fed ones *viz.*, that the former were often nervous and irritable and if they lived together in colonies, the stronger preyed upon the weaker while the well-fed ones were placid, good-tempered and tractable. These experiments on rats on a large scale and extending over three years as well as experiments made on other species of animals *viz.*, guinea-pigs, rabbits, monkeys and

1. From an article by McCarrison on "Food : The Foundation of Health."
2. *Ibid.*

pigeons undoubtedly showed that keeping all other factors the same and changing only one factor *viz.*, food, the well-fed animals were practically free from disease and ill-fed animals suffered from diseases of many kinds. It is reasonable therefore to assume that the human species would be no exception to this rule.

The question which naturally arises out of these considerations is whether it would be possible to keep children practically free from disease as McCarrison was able to do in the case of animals. The answer is in the affirmative. It has been shown by Miss Margaret McMillan of the Nursery Schools, London, that ailments acquired by children as a result of faulty nutrition could be got rid of by proper attention to their diet. She writes in her book (The Nursery School 1930), "after the weakly and ill-conditioned children have been nurtured and properly fed by her for three or four years they are almost all cured of any ailments from which they may have suffered on their entrance to the school." The most important conclusion which McCarrison has reached from the numerous experiments made by him on different species of animals for a period extending over three years is that faulty feeding is the cause of so many defects one sees in the building of the body and of so many ailments one comes across in children and that disease and physical inefficiency in later life are to be traced to these defects consequent on faulty feeding.

There are many factors affecting the health and physique of the industrial workers; of all these *food* plays the most important part. The Royal Commission on Labour in India 1931 draws attention at many places in its report to the important question of physique and dietary and the part played by defects of dietary. Writing about the cotton mill workers in Bombay it states that 'the low grade of physique among these people is largely due to poor constitutions from birth and to a deficient diet'. Writing about the cotton mill workers in Ahmedabad it states that 'the immigrants from Kathiawar, Rajputana and the United Provinces, who work in Ahmedabad, have a better physique than the local labour force, the variation again being due to differences in diet'. Writing about the Bengal Jute Mill workers it states that 'operatives from up-country are usually sturdier than the Bengalis and evidence indicates that the emigrant from North India ordinarily resists industrial fatigue well, his diet and constitution standing him in good stead'. Writing about the miners it states that 'the satisfactory physique of the Santals is attributed to a better dietary and to the fact that they return regularly, often every week-end, to their village homes'. While reviewing the health conditions of the chief groups of Indian industrial workers it states that "impaired physique and defective diet are, however, features common to many and the severe handi-

caps to industrial development which these factors represent demand attention from all concerned."

The following examples taken from McCay's book[1] show clearly the relative productive capacity of the poorly-fed Indian and the better-fed English worker :—

	England	India
Operatives per 1000 spindles	4·2	28
Operatives per 1000 looms	43	125
Annual outturn of yarn per operative	7736 lbs.	4000 lbs.
Weekly outturn of cloth per operative	767 yds	240 yds
Working hours per week	$55\frac{1}{2}$	80
Working hours per year	2775	4120

The above figures are pre-war figures. The working hours per week at the present day are 48 for England and 60 for India.

The figures given by Arno S. Pearse[2] when making a comparative statement between (1) a cotton mill in the Southern States of America and a first class cotton mill in Bombay both turning out the same kind of cloth and (2) an up-to-date Bombay mill and an Oldham Mill of the same size, are recent and very illuminating :—

		America	Bombay
(1)	No. of spindles	23000	25000
	No. of looms	800	800
	Working hours per week	60	60
	No. of hands	329	970
	Production per man	250·9	81·6
		England	Bombay
(2)	Production per man per hour	6·4	3·79

In a statement made by the Ahmedabad Millowners' Association to the Tariff Board in 1926 the following facts were mentioned :

". . . . . . . about the close of the last century whereas an operative in Bombay worked on an average only 40 spindles, his contemporary in Italy worked 80 spindles, in Alsace 100, in Switzerland and Bavaria 150 each, or approximately four times as many as an operative in Bombay. The German operative worked during the same period 170 spindles approximately, whereas an operative in England on an average (in 1887) 333 spindles, or over eight times as many as an operative in Bombay (1895). There can be no comparison whatsoever between the spindles managed by a single girl operative in the U. S. A. and those managed by an operative in Bombay. Bombay's

1. "The Protein Factor in Nutrition" by McCay (1911)
2. "The Cotton Industry of India" by Arno S. Pearse (1930)

'40 spindles per operative' would appear as a drop in the ocean before American's 896 to 1200 spindles per operative."

Arno S. Pearse in his Report on the cotton Industry of India 1930 gives the following figures: speaking about Japan he writes, "Operatives work as many machines as can be attended under fair conditions, actually upto three sides of a spinning frame and 5·5 looms per operative (against one side and less than two looms in India)."

Though the wage per operative is much lower in India than in England and Japan yet the cost of production in India is much higher than in Japan and England; this is principally due to the poor efficiency of the Indian operative; this again is due, among other causes, to his frail constitution which results from his unsound feeding, and living under insanitary conditions. In calculating the outturn of cloth or yarn per operative in different centres one has to consider the counts of yarn, the type of machine etc; it is, therefore, difficult to give comparative figures. But as regards the relative productive capacity of the Indian and English and Japanese operatives there are no two opinions that the output per operative in India is less than in England and Japan.

If we now turn our attention to the yearly output of coal per man working in a coal mine which perhaps gives the best comparative tests of the capabilities of two classes of workers (well-fed Europeans and ill-fed Bengalis) we get the following figures :—

England	300 tons.
Germany	243 „
Bengal	80 „

The physical conditions were all in favour of the Bengali and yet the result is an outturn barely 27% of that of the European (McCay).

If we take the average outturn of bricks per day per man in Ahmedabad and compare it with that of the old-fashioned brick-maker of the United States of America we get the following figures :—

	U. S. A.	India
Average outturn of brick a day per man	450	262

Take again the case of a young Bhutia woman of 18 years of age; she is known to carry a load. of 200 lbs. over long distances and uphill tracts. To work 12 hours every day is not an unsual thing to a Punjabi Agriculturist.[1] This capacity for endurance and hard work depends largely, according to McCay, on the level of protein metabolism to which their food enables them to attain. The output of work in each case is in direct relation to physical efficiency which again is a result of the constitution of food.

1. Vide Appendix C.

If the physical efficiency of a worker is, above all, a matter of constitution of his food as has been shown above and if the output of work is in direct relation to his physical efficiency it is not a matter of surprise that the output of our ill-fed Indian labourer is very small. If that is actually the case then what steps should be taken to increase his physical efficiency and consequently his output of work. Would the average Indian worker even if he possessed the means to provide himself with a diet which would satisfy his physiological needs actually spend his money on suitable food or know how to choose a well-balanced dietary? Very probably not. McCarrison puts forward a most important suggestion in this connection which deserves the most careful consideration of our industrialists and the directors and owners of our textile mills and other big works. He suggests that 'where possible workers be provided daily as part of their earnings with a properly constituted meal or that they receive part payment in kind in the form of food-materials.' The trouble involved in this would be more than repaid in the increased output of work.

This proposal of providing a properly 'constituted meal' to mill operatives is no longer in deliberative or experimental stage in Japan. It is gratifying to note that the mill authorities there supply food to practically all their workers ; all food supplies could be had 20 to 30% cheaper at the mill stores than in the town. The description given by Arno S. Pearse in his report on the *Cotton Industry of Japan and China* (1929) about the dining halls attached to the mills is worth noting by our millowners here. " The dining halls are plain, specklessly clean, and the kitchens are like special factories. The food is carefully selected according to the latest Scientific caloric contents and supervised by doctors."[1]

The facts noted above show that stature, body weight, stamina, capacity for endurance and hard work, resisting power against desease, physical efficiency, output of work,—all these depend upon the dietaries of the different classes and races of men. The output of

1. The proposal of opening big communal kitchens in mill area for the labouring population where only smokeless fuel would be used was made by the author of this paper as one of the remedies to diminish the smoke nuisance in the city due to domestic smoke at the Smoke Abatement Conference held in Ahmedabad under the Chairmanship of the President of the AhmedabadMunicipality in 1931. It was gratifying to him to note that his proposal which was supposed to be impracticable was not only anticipated but actually successfully followed in Japan by the Mill authorities there. It was equally gratifying to him to note that a similar proposal of providing meals to the workers in the mills was made by Major-Gen. Sir McCarrison in the evidence he gave before the Royal Labour Commission in the year 1927 but from a different point of view *viz.*, to increase the physical efficiency of the Indian workers.

work by the human machine is closely related to the quality of food with which it is provided. Does this mean that one has to spend more money to get better and more nutritious food? No, it is not so: the most essential thing is to know how to prepare a *well-balanced* diet. An ordinary dietary containing simple wholesome foods in the right proportion is far better and cheaper than a dietary consisting of rich foods but which are not properly balanced. To understand this we must know the chemical composition and the biological values of the different food-stuffs that we eat and which are necessary for the physiological needs of the body.

Our body is made up of the following elements:—

Non-metallic elements: Oxygen, Carbon, Hydrogen, Nitrogen, Phosphorus, Sulphur, Chlorine, Fluorine, Silicon.

Metallic elements:—Calcium, Potassium, Sodium, Magnesium, Iron, Manganese.

These elements are combined together in various proportions to form the following groups of substances of which the body is composed:

Water—present in all tissues.

Salts—present in all tissues.

Proteins are complex organic compounds which contain carbon, hydrogen, oxygen and nitrogen and sometimes sulphur, phosphorus and iron.

Fats are compounds of glycerine with fatty acids.

Carbohydrates are substances like starch, sugar or gum and contain carbon, hydrogen and oxygen, the latter two elements in the right proportion to form water; they are therefore called carbohydrates.

For convenience of study the food principles may be further classified as follows:

Tissue formers & Body builders	Work and heat producers.
Proteins	Proteins
Salts	Carbohydrates
Water	Fats

The main function of animal life is oxidation. More oxygen is used than the weight of all solid foods. When air is inhaled oxygen which is present in it is abstracted by the hæmoglobin (red colouring matter) of the blood in the capillaries of the lungs. Living in close rooms lowers the vitality to an extent little dreamt of by many.

We need food for two purposes:

(1) to maintain our body heat and

(2) to produce new cells and to make up for the wear and tear of our bodies.

Food-materials are, therefore, divided into two principal classes (1) heat and energy producers and (2) body builders and tissue formers.

Carbohydrates, oils and fats are heat givers;

Proteins, mineral salts and water are body builders.

A complete classification of foods is shown in the diagram given below :—

Foods

- Organic
  - Nitrogenous (Proteins) (body builders, principally; also heat givers)
    - Animal Proteins. Sources :— (a) milk & milk products (b) meat, fish, fowl.
    - Vegetable Proteins. Sources :— (a) cereals: wheat, rice, pulse, millet etc. (b) legumes, peas, etc.
  - Non-nitrogenous (heat givers)
    - Carbohydrates Sources :— (a) starches (b) sugars
    - Oils and fats
      - Animal Sources :— (a) animal fat (b) butter, ghee.
      - Vegetable Sources :— (a) vegetable oils.
- Inorganic (Mineral salts) (body builders) Sources :— (a) fruits (b) vegetables (c) milk

All foods must be subjected to the following six tests in order to ascertain their relative value :—

1. The Physical Test—How much potential energy is the food capable of yielding ?

2. The Chemical Test—What percentage of each nutritive principle (protein, carbohydrate and fat) does the food contain ?

3. The Physiological Test—How does the food behave in the stomach and intestine ?

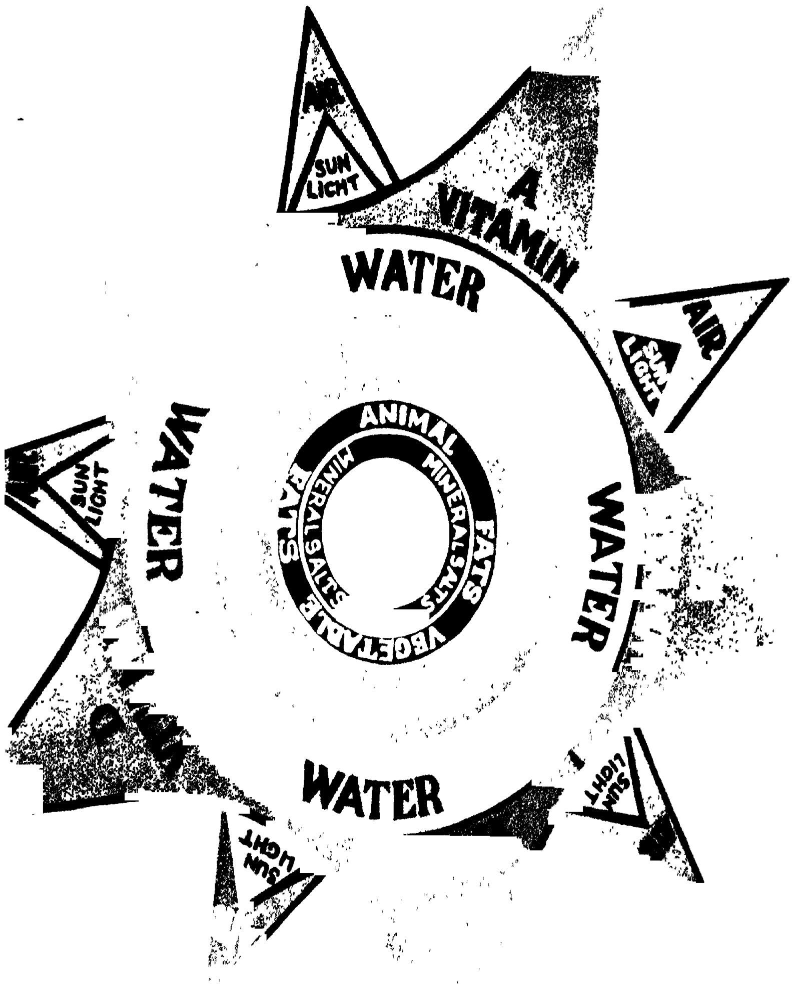
4. The Biological Test—What vitamins and how much of each does the food contain ?

5. The Economic Test—Are the nutritive constituents of the food obtained at a reasonable cost ?

And shall we add also

6. The Psychological Test—Is the food palatable ?

Let us now examine these tests somewhat in detail.


AIR
SUN LIGHT
A VITAMIN
WATER
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AIR
SUN LIGHT
AIR
SUN LIGHT
SUN LIGHT
SUN LIGHT
ANIMAL
MINERAL SALTS
FATS
VEGETABLE
MINERAL SALTS
FATS

The Physical Test—The food-stuffs that we eat differ in their power to produce energy; their 'energy-value' varies; it can be measured in 'calories'. A calorie is the amount of heat required to raise the temperature of one kilogramme (2·2 pounds) of water through one degree centigrade. One gramme of pure protein and carbohydrate has each an energy value of 4 calories. One gramme of fat has an energy value of 9 calories. According to McCarrison an Indian in prime of life requires each day from 2,500 to 3,500 calories according to the part of India in which he lives and the nature of work he has to do; an Indian woman requires four-fifths of this amount, or from 2,100 to 2,900 calories.

The Chemical Test.—The following proportions of proteins, fats and carbohydrates in their diets are recommended for Indians living in different parts of India :—

	North of India.	South, South-east and South-west of India.
Proteins	90 to 100 grms.	60 to 70 grms.
Fats	80 to 90 „	50 to 60 „
Carbohydrates	360 to 450 „	Sufficient to make the total requirement of calories.
Total calories	2,520 to 3,010.	

Again the proportion of animal protein should not be less than 33% of the total protein in the diet and that of animal fat not less than 50% of the total fats in our diet. Only when our dietary contains food-stuffs which yield proteins, fats and carbohydrates in the proportions given above will it be said to be well-balanced and to properly fulfil its function. (Diagram 3). It is not enough to know that the protein, fat and carbohydrate are in the right proportion but it should also be seen that they are of the right kind. An animal fed on gelatine (protein), olive oil (fat), and straw (carbohydrate), no matter how much of each is given, would not keep healthy and would eventually meet with certain death for the food constituents are not of the right kind.

What is wanted is the right weight of the body according to the height and age of the individual, neither underweight nor overweight; that is an indication of good health. " Mens sana in corpore sano". Body and mind are so intimately related and act and react so much on each other that a sound mind naturally results from a sound body.

The principal defects of Indian diet are (1) too little suitable proteins, (2) too little animal fat and (3) a large excess of carbohydrates. The best way to make up for deficiencies in the first two is to use plenty of milk and milk products and green leafy vegetables and fruits. Two examples of well-balanced and two of badly-balanced diets, are given in the Appendix C which bring out the facts mentioned above very clearly; also an example of an average diet used in one of the local students' hostels (Appendix D.)

The proportions of proteins, fats and carbohydrates in some of the important Indian food-stuffs with their vitamin contents and the amount of calories they yield are given in Appendix B. One can easily find out from this table whether one's diet is well- or ill-balanced.

The Physiological Test.—The food to be digestible must be capable of being absorbed but it should also contain some residue of husks or fibres which would act as a ballast in the intestine. If a food is cent percent digestible it would produce constipation. A thorough mastication of the food is also essential. Again it should be stated that it is not what a man eats that gives him strength but what he digests and assimilates.

The Biological Test.—Over and above the proteins, fats, carbohydrates, mineral salts and water we require certain other substances in our food which are body builders and are essential to life; they are called vitamins; their absence or deficiency in food prevents growth of body, gives rise to certain diseases, known as deficiency diseases and ultimately produce death. They are present in such infinitesimally small quantities in the foods that only some of them have yet been seen or weighed.[1] They are like a spark which ignites the fire of nutrition. They are all present in the foods which nature supplies us for our use but we should see that we do not inadvertently spoil our foods by removing the vitamins from them or by killing the vitamins in them before we eat them.

The law of growth of animal life is that it must depend for its subsistence upon plant life. Men and animals have not got a mechanism in their physical bodies to make their own food as the plants do. They must have it prepared for them by the plants, directly or indirectly, for the plants are organisms endowed with a capacity for transmuting inorganic minerals into organic ones and for manufacturing the most vital food-factors, the vitamins. It is now well known how important these organic minerals and vitamins are not only for maintaining the bodies but also for building them.

The classical experiments carried out by Gowland Hopkins on two groups of rats conclusively prove the important part played by the vitamin A in the growth of animals. The open circles in diagram 4 indicate rats fed on artificial milk (absence of vitamins), solid black dots indicate rats fed on artificial milk plus a teaspoonful of natural milk containing the vitamin A. It will be seen from the diagram that the rats fed on artificial milk diet only were losing in weight and the other group which was given a teaspoonful of natural milk along with the artificial milk was gaining in weight; this went on till the 18th day when the experiment was reversed and the diets were exchanged with the result that those which were losing weight now began to grow and

1. Vide Appendix I.

gain in weight and those which were increasing in weight now began to lose weight and grow languid. Again a diet deficient in vitamin A causes also inflammation of the eye, lungs, intestines, bladder etc; the first of which may even end in total blindness in some cases. A dog suffering from ophthalmia as the result of a diet deficient in vitamin A was cured in 10 days by the addition to his diet of 20 cc. of cod-liver oil per day (Stenlock, Nelson and Hart). An adequate supply of this vitamin causes not only growth but is one of Nature's surest safeguards against infection from pathogenic bacteria. Vitamin A is slowly destroyed by cooking.

Experiments made on pigeons fed on polished rice and unpolished rice showed a similar result. The polished rice are wanting in an important vitamin B which is present in the unpolished rice. Those fed on polished rice began to lose their appetite, became very thin, suffered from diarrhœa, got paralysis and died; but if to the polished rice were added the rice polishings in time then the tragedy was averted. A dog suffering from marked paralysis of hind legs as the result of a diet lacking in vitamin B was cured in a short time by supplying that vitamin in the form of tomato juice (Cowgill and Mendel).

Experiments by Gowland Hopkins on two groups of eight rats.
Solid black dots—artificial milk + 3 cc. fresh natural milk (a small teaspoonful)
Open circles—artificial milk only. (Basal diet)

DIAGRAM 4.

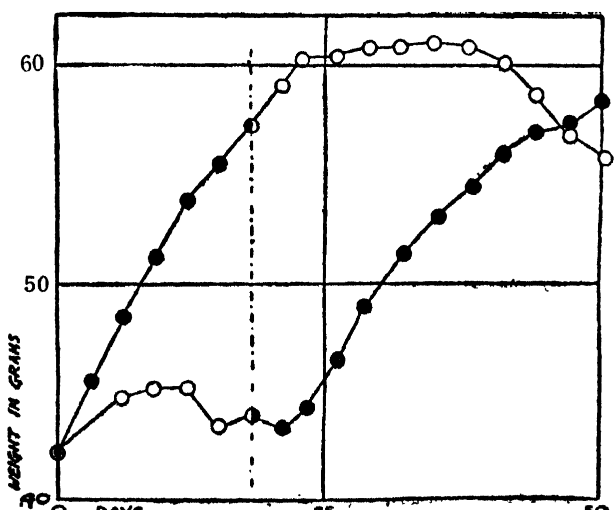

FIG. 1.

Growth curves showing the influence of Vitamin A on rats.

It was noticed that sailors used to suffer from a disease called scurvy during long voyages when they could not get fresh vegetables and fruits to eat. In this disease the gums become sore and bleed, the legs swell and pain; this is prevented or those suffering from this disease rėcover if they are given the juice of lemons. This is because green leaves, vegetables and fruits contain another vitamin called C. This vitamin is killed by cooking, storing and tinning.

Rickets, a disease of darkness and civilisation, is another malady known to be associated with food which is wanting in vitamin D, which is usually present in milk, butter, eggs or cod-liver oil. A child living in a dark and gloomy house, who does not get enough milk or who is fed on milk from a cow that has been kept in a dark stable contracts this disease. But if the child lives in open sunlight, or the milk and cow are exposed to sufficient sunlight, or subjected to ultra-violet rays then the disease does not occur. The story of the discovery of the Vitamin D is most fascinating. It has brought out most clearly the cor-relation between darkness and disease. The natural method of procuring Vitamin D is to eat foods containing ergosterol which is fortunately very widely distributed in all kinds of natural food-stuffs and then to have this activated in the skin by the ultra-violet rays of the sun. The understanding of the mechanism of the formation of Vitamin D has brought into prominence the health giving properties of sun-light and the important part played by the skin, —a vital organ of the body as a reservoir of light to human welfare. Anything which prevents the direct access of sunlight to skin such as a cloudy atmosphere, smoke pollution of the air, clothes, indoor life, means so much loss to health and physical efficiency. The rationale of light clothing and open-air life will thus be evident.

It is impossible to write all about this interesting and important subject in a short article like this. I would strongly recommend those interested in this subject and who are anxious to prepare their dietaries on right lines to read the excellent little booklet by Major-Gon. Sir McCarrison on Food which could be had for the trifling price of As. 12/- only but which is worth its weight in gold.

The Economic Test.—A lunch of bread and skim milk at 2 annas yields as many calories (i. e. heat and energy) as a lunch of soup, beef, potatoes, turnips, bread, butter, milk and sugar in coffee at 8 annas; it is therefore more economical as it is 4 times cheaper.

Of all the foods milk is the ideal food and of all the milks mother's milk is the best for an infant. The health of an infant depends so much on its mother's milk and the quality of the milk depends so much on the food the mother takes that too much attention cannot be given to her diet which should be properly balanced. Suppose the diet of the mother is deficient in calcium, phosphates and vitamins

which are essential for the formation of teeth and bones, her milk will also be deficient in these salts and vitamins; now if the infant is fed on such a milk there is no wonder that it will suffer from rickets or that its teeth will be bad; with such a handicap from the very beginning it will have less resisting power against disease, and will, therefore, practically be a weakling incapable of carrying on the ordinary duties of life. How far reaching the results of a well- or ill-balanced diet are is evident from the above example. Again an infant is likely to suffer from anæmia if fed exclusively on milk diet for more than six months for milk is deficient in iron and deficiency in iron leads to impoverishment of the blood and check in growth.

The best form in which milk should be taken in our country is in the form of sour milk, curds etc. when one is not absolutely sure of the purity of the fresh milk. Whole wheat and unpolished rice are always to be preferred to white flour and polished rice. Tea and coffee have no food values (vide appendix B).

Of the combinations bread and milk and bread and apple, milk was found to be superior to apple as a nutritional supplement of bread, for of two rats (twin sisters) of equal size and equally healthy and vigorous at weaning time the one fed on bread and milk grew to five times the initial weight while the other fed on bread and apple remained stationary (Sherman, Rouse, Allen and Woods 1921).

Of the combinations bread and milk, bread and butter and bread and meat the first was found to be superior to the other two from the point of view of growth.

Attention is drawn here to the importance of the use of the Soya bean as a very nutritious article of food in our country where the bulk of people do not use animal food. In one ounce of the Soya bean we get 9·6 grms. of proteins, 4·9 grms of fat and 9·5 grms of carbohydrates. It also contains three vitamins A, B, and D and its proteins have a relatively high "biological value." In fact from the study of the properties of the Soya bean it is expected to be a cheap and valuable substitute for meat, milk, egg and cod-liver oil. Soya bean crop is extensively grown in China and is used in various ways in human nutrition in China and Japan. It is very necessary that such an article of food should be produced[1] on a very large scale in our country and supplied very cheap to the people and its use popularised.[2]

The facts given above show what an important subject the subject of nutrition is; how vitally it is connected with questions of health and disease, of physical and industrial efficiency and output of work, and

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1. It is gratifying to note that experiments carried out in Sindh, Poona etc. show that the Soya bean can be successfully grown in our country.

2. For further information regarding the composition and uses of the Soya bean vide Appendices E, F, G and H.

with the all important question of producing various types of the human race. "*As knowledge with regard to the effects of food upon man increases, it is more than conceivable that races that first avail themselves of the new values of nutrition may decrease the handicaps of disease, lengthen their lives and so become the leaders of the future*". (Food and Race, by Victor Heiser, Foreign Affairs, Vol. VI. Page 427.)

If India is to become a strong and virile nation then it is the duty of Government, Municipalities, Educational and other public bodies and the leaders and panchayats of every community to see that no boy or girl leaves the school without getting an adequate knowledge of the important subject of dietetics and that no section of the public is without cheap and scientific dietaries suitable to its taste, purse and need.

In the preparation of this article I have drawn upon freely from books and journals treating of food and vitamins. To the authors of all these papers I desire to express my thanks. To Major-General Sir McCarrison and Principal G. Findly Shirras my special thanks are due for placing at my disposal a good many materials on the subject. I am again grateful to Major-Gen. Sir McCarrison and Messrs. Macmillan and Co., Madras, for permitting me to reprint diagrams 1, 2 and 3.

APPENDIX A. *

SIKH DIET.

(As given to the rats—Diagrams 1 and 2.)

Whole wheat chapatis.
Green vegetables in plenty.
Butter.
Sprouted gram.
Fresh milk in plenty.
Occasionally meat.

MADRASSI DIET.

(As given to the rats—Diagrams 1 and 2.)

Rice.
A small quantity of dhal and vegetables.
A small quantity of ghee.
Tamarind water.
Little buttermilk.
Betel nuts.

* This shows the Sikh and Madrassi diets on which the rats were fed by McCarrison in the classical experiment described on page 241.

APPENDIX B.*

Proteins, fats and carbohydrates in grammes per ounce, calorie-value and vitamin content of common food materials used in India :—

Food-stuffs.	Proteins in Grms.	Fats in Grms.	Carbohydrates in Grms.	Calories per Ounce.	Vitamins. A	B	C	D
Milk and Milk-Products								
Cows' Milk	0·94	1·02	1·36	18	† † †	† †	†	†
Human Milk	0·42	1·50	0·75	18	† to ††	†	†	...
Cream	0·70	5·24	1·27	55	† † †	†	...	†
Cheese	7·35	8·88	0·50	111	† †	V.L.	...	...
Butter Milk	0·85	0·14	1·36	10	†	†	†	...
Skimmed Milk	0·96	0·08	1·44	10	†	†	†	...
Dadhi	1·40	1·00	0·80	18	† †	†	†	...
Sheep's Milk	1·50	2·00	1·41	30	† † †	†	†	†
Goat's Milk	1·21	1·13	1·21	20	† † †	†	†.	†
Buffalo's Milk	1·35	2·18	1·24	30	†††	†	†	†
Flesh, Meat and Eggs								
Lean Beef	6·20	2·06	...	43	V.L.	†	V.L.	†
Lean Mutton	5·97	1·98	...	42	V.L.	†	V.L.	†
Goat's Meat	7·20	0·75	...	36	0	†	V.L.	0
Pork	6·05	3·14	...	53	0	†	0	...
Bacon	5·00	15·00	...	155	0	...	...	...
Liver	6·11	1·70	0·76	43	† † †	† † †	†	†
Kidney	4·54	1·36	0·06	31	† †	† †	...	...
Brain	2·90	2·77	...	37	†	† †	...	...
Tongue	4·41	5·43	...	67	0	†	...	...
Fat Fish	5·32	3·70	...	55	† † †	†	...	...
Non-fat Fish	5·15	0·20	...	22	...	†	...	...
Freshwater Fish	5·50	1·15	...	32	...	†	...	...
Chicken	6·74	0·38	...	30	†	...	...	...
Duck	5·80	2·94	...	50	†	†	...	...
Pigeon	6·25	1·86	...	42	†	†	...	...
Egg	3·79	2·97	...	42	††	† † †	...	†
Animal Fats								
Beef fat, Mutton fat	0·34	26·40	...	239	† †	...	...	...
Lard	...	26·80	...	241	0 to V.L.	...	...	...
Butter and Ghee	...	23·10	...	208	† † †	...	...	†
Cod-liver Oil	...	28·00	...	252	† † †	V.L.	...	† † †
Fish-liver Oil	...	28·00	...	252	† † †	V.L.	...	† †
Vegetable Oils								
Cocoanut Oil	...	28·00	...	252	†	0	0	V.L.
Gingelly Oil	...	28·00	...	252	V.L.	0	0	0
Linseed Oil	...	28·00	...	252	V.L.	0	0	...
Ground-nut Oil	...	28·00	...	252	V.L.	0	0	V.L.
Olive Oil	...	28·00	...	252	V.L.	0	0	...
Cotton-seed Oil	...	28·00	...	252	V.L.	0	9	...
Mustard Oil	...	28·00	...	252	0	0	0	...
Cocogem	...	28·00	...	252	0	0	0	...
Margarine	...	23·80	...	214	0 to †	0	0	...

* Reprinted from 'Food' by Major-Gen Sir McCarrison by kind permission of the author.

Food-stuffs.	Proteins in Grms.	Fats in Grms.	Carbohydrates in Grms.	Calories per Ounce.	Vitamins.			
					A	B	C	D
Sugars and Starches								
White Sugar	...	...	28·30	113	0	0	0	...
Brown Sugar	...	...	26·89	108	0	0	0	...
Goor or Jaggery	0·08	...	25·00	100	0	V.L.	0	...
Honey	0·11	...	20·21	81	V.L.	V.L.	0	...
Tapioca	0·05	0·01	24·83	100	0	0	0	...
Sago	2·18	0·04	22·00	97	0	0	0	...
Sugar Cane	0·42	0·16	6·20	28	...	†	†	...
Cereal Grains & Bread								
Wheat (atta)	3·90	0·54	20·35	102	†	† †	0	...
White Flour	3·14	0·37	21·54	102	0	V.L.	0	...
Unpolished Rice	2·30	0·085	22·30	99	V.L,	†	0	...
Washed Rice	1·62	0·15	26·34	113	0	0	0	...
Polished Rice	1·79	0·13	26·09	113	0	V.L.	0	...
Parboiled Rice	1·84	0·22	26·11	114	0	†	0	...
Ragi or Bajri	2·78	0·46	23·35	109	† to ††	† †	0	...
Cambu	3·64	1·38	19·40	105	†	† †	0	...
Cholam	2·90	1·17	19·70	101	†	† †	0	...
Barley	2·97	0·62	20·60	100	†	† †	0	...
Oat-meal	3·37	2·43	19·81	115	†	† †	0	...
Maize (yellow)	2·13	0·48	20·80	96	† †	† †	0	...
White Bread	2·00	0·33	14·80	70	0	†	0	...
Suji or Semolina	4·00	0·68	14·20	80	†	† † †	0	...
Rice Polishings	...	...	...	...	†	† †	0	...
Dhals, Peas & Beans								
Fresh broad beans	2·661	0·11	6·45	37	†	† †	† †	...
Fresh French beans	0·54	0·03	1·36	8	†	† †	† †	...
Peas (dried)	1·85	0·17	4·75	28	†	† †	0	...
Dhals	6·50	0·99	16·20	100	†	† †	0	...
Grams	5·70	1·30	16·30	96	†	† †	0	...
Soya Bean	9·60	4·70	9·50	119	†	† †	0	...
Nuts and Seeds								
Almonds	5·26	15·96	4·30	182	V.L.	† †	0	...
Cocoanut	1·61	14·31	7·90	167	†	† †	0	...
Groundnut	7·30	10·92	6·90	155	V.L.	† †	0	...
Walnut	3·85	19·92	3·96	211	V.L.	† † †	0	...
Other Nuts	5·00	16·50	3·60	183	V.L,	† †	0	...
Linseed	6·40	9·50	7·60	142	† to ††	† †	0	...
Tuber and Root Vegetables								
Potato	0·70	0·04	8·15	36	V.L.	†	† to ††	...
Beetroot	0·34	0·03	1·75	9	V.L.	†	†	...
Celery	0·17	0·03	1·07	5	...	† † †	† †	...
Onions	0·37	0·03	3·06	14	V.L,	† †	†	...
Garlic	1·92	0·03	7·90	40	†	†	† †	...
Carrots	0·25	0·03	2·26	10	† to ††	† †	† to ††	...
Leeks	0·71	0·03	2·63	14	†	†	† †	...
Parsnips	0·48	0·14	5·97	27	V.L.	†	† to ††	...
Radishes	0·28	0·03	0·96	5	V.L.	†	†	...
Turnips	0·34	0·03	1·25	7	V.L.	† †	†	...
Yams	0·51	0·06	6·31	28	...	†	†	...
Fleshy roots (Taro)	0·50	0·06	6·30	28	...	†	†	...

Food-stuffs.	Proteins in Grms.	Fats in Grms.	Carbohydrates in Grms.	Calories in per ounce.	Vitamins.			
					A	B	C	D
Green Leafy Vegetables								
Brussels Sprouts	0·92	0·06	1·61	11	†	†	† †	...
Cabbage	0·39	0·03	1·27	7	† † †	† †	† † †	...
Lettuce	0·31	0·06	0·54	4	† †	† † †	† †	...
Spinach	0·51	0·06	0·82	6	† † †	† † †	† † †	...
Turnip Tops	1·19	0·17	1·78	13	† † †	† † †	† †	...
Other Vegetables								
Tomatoes	0·20	0·03	1·27	6	† †	† † †	† † †	...
Rhubarb	0·17	0·02	1·03	5	...	...	†	...
Cucumber	0·17	0·02	0·57	3	...	†	† †	...
Pumpkins	0·28	0·03	1·47	7	...	†	†	...
Brinjal	0·34	0·09	1·44	8	...	†	†	...
Cauliflower	0·54	0·06	1·67	9	†	†	†	...
Bhendi (Ladies fingers)	0·57	0·33	1·70	12	...	†	†	...
Knol-khol	0·26	0·16	3·30	16	V.L.	†	†	...
Artichoke	0·78	0·06	5·00	24	...	†	†	...
Asparagus	0·68	1·00	0·66	14	†	† † †	†	...
Potal	0·21	...	0·37	2	...	†	†	...
Fresh Fruits and Berries								
Apples	0·09	0·06	3·54	15	...	†	†	...
Bananas or Plantains	0·45	0·03	2·26	11	V.L.	†	†	...
Grapes	0·17	0·03	3·93	17	...	†	V.L.	...
Lemons	0·14	0·14	0·88	5	...	†	† † †	...
Oranges	0·25	0·03	2·69	12	†	†	† † †	...
Pears	0·09	0·03	2·29	10	...	†	†	...
Pomegranates	0·18	...	0·19	2	...	†	†	...
Peaches	0·19	0·03	2·66	12	...	...	† †	...
Pineapple	0·11	0·09	2·75	12	...	...	† †	...
Watermelons	0·11	0·06	1·90	9	...	...	†	...
Papaya	0·16	...	1·10	1	†	†	† †	...
Lichee	0·84	0·07	1·90	12	...	†	† †	...
Mango	0·04	0·22	5·20	23	†	...	† †	...
Guavas	0·37	0·20	2·27	12	...	†	†	...
Dried Fruits								
Apricots	1·56	0·09	14·04	63	...	...	0	...
Currants	0·48	0·09	11·89	50	...	0	0	...
Dates	0·45	0·03	19·73	81	...	†	0	...
Figs	0·56	0·14	15·99	67	...	†	0	...
Prunes	0·85	0·09	11·43	50	...	†	0	...
Raisins	0·62	0·09	17·32	73	...	†	0	...
Tamarind	0·39	...	8·89	37	...	†	†	...
Miscellaneous								
Jams	0·06	...	19·81	79	0	0	0	...
Marmalade	0·06	...	19·41	78	0	0	0	...
Treacle	0·06	...	16·95	68	0	0	0	...
Condensed Milk	2·49	2·35	15·31	92	†	†	0	...
Pickles	0·31	0·11	1·13	7	...	...	...	...
Pepper	4·39	2·41	17·83	111	...	...	...	...
Infant foods (Tinned)	3·59	0·93	21·56	109	...	...	0	...
Sandesh	5·40	6·00	12·00	124	0	0	0	...
Tea	...	...	...	...	0	0	0	...
Coffee	...	...	...	...	0	0	0	...

Three Crosses († † †) mean 'rich in';
Two Crosses († †) mean 'moderately rich in':
One Cross (†) means 'some' or 'poor in'
0 means 'none'
V.L. means 'very little'

A blank space in the columns under 'vitamins' means that the vitamin-content has not been estimated;

Calories are given in round numbers;

One ounce equals 28·3 grammes.

APPENDIX C.

Examples of well-balanced diets

1. Punjabi Agriculturist. *

	Quantity in ozs.	In grammes. Proteins.	Fats.	Carbohydrates.
Atta (Whole wheat flour) ...	20	78·00	10·80	407·00
Dhal	1	6·50	0·99	16·20
Vegetables	10	3·10	0·60	5·40
Sugar	2	0·16	...	50·00
Curds	4	5·60	4·00	3·20
Butter	2½	...	57·70	...
Milk	20	18·80	20·40	27·20
Buttermilk	40	34·00	5·60	54·40
Total ...	...	146·16	100·09	563·40
Animal origin ...	...	58·40	87·70	...
Less 10% for waste ...	...	14·61	10·00	56·34
Balance ...	...	131·55	90·09	506·06
Calories ...	...	539·4	837·8	2074·8

Total Calories ... round numbers 3452

* From the report of the evidence before the Royal Labour Commission by Major-General Sir McCarrison.

2. Certain races of Northern India.*

	Quantity in Ozs.	In grammes. Proteins.	Fats.	Carbo-hydrates.	Calories.
Atta ...	12	46·80	6·48	244·2	1222
Rice (home pounded)	6	13·10	0·51	133·8	595
Meat (mutton) ...	2	11·94	3·96	0·0	84
Milk ...	20	18·80	20·40	27·2	360
Vegetable oil ...	1	0·00	28·00	0·0	252
Ghee ...	1·5	0·00	34·60	0·0	312
Root vegetables ...	8	4·40	0·36	31·8	148
Cabbage ...	8	3·10	0·24	10·2	56
Mango ...	4	0·16	0·88	20·8	92
Dhal ...	1	6·50	0·99	16·2	100
	63·5	105·50	94·42	484·2	3221
Les 10% for waste	6·3	10·50	9·64	48·4	322
Total ...	57·2	95·00	86·78	435·8	2899

APPENDIX C. (continued).

*Examples of badly balanced diets**

1. The poor Hindu family diet.

	Quantity in Ozs.	In grammes. Proteins.	Fats.	Carbo-hydrates	Calories.
Polished rice ...	21·0	37·60	2·70	547·9	2373
Dhal ...	0·7	4·50	0·70	11·3	70
Black gram ...	0·7	4·00	0·90	10·7	67
Vegetable oil ...	0·1	0·00	2·80	0·0	25
Vegetables ...	2·0	1·10	0·10	7·7	36
Meat or fish ...	0·06	0·40	0·05	0·0	2
Coconut ...	0·05	0·08	0·72	0·4	10
	24·61	47·68	7·97	578·0	2583
Less 10% for waste	2·40	4·76	0·79	57·8	258
	22·21	42·92	7·18	520·2	2325

* From "Food" by McCarrison.

This diet contains too little proteins, all of which is of vegetable origin, far too little fat, too much carbohydrate and not enough calories. It is dangerously low in all the vitamins, especially A and B and it is deficient in salts notably of calcium, phosphorus and iron. The family living on this diet were of low vitality, incapable of sustained hard work and prone to bowel complaints.

2. The well-to-do Hindu family diet. (South India).*

	In grammes.				
	Quantity in Ozs.	Proteins.	Fats.	Carbo-hydrates.	Calories.
Polished rice ...	23·0	41·2	3·0	600·0	2599
Dhal ...	1·2	7·8	1·2	19·4	120
Gram ...	1·9	10·8	2·5	29·0	182
Vegetable oils ...	1·2	0·0	33·6	0·0	302
Ghee ...	0·4	0·0	9·2	0·0	83
Curds ...	9·0	12·6	9·0	7·2	162
Vegetables ...	6·0	2·0	0·5	8·6	48
Cocoanut ...	2·0	3·2	28·6	15·8	·334
Sugar ...	1·0	0·0	0·0	25·0	100
Milk ...	7·0	6·5	7·1	9·5	126
	52·7	84·1	94·7	714·5	4056
Less 10% for waste	5·2	8·4	9·4	71·4	405
	47·5	75·7	85·3	643·1	3651

This diet is too poor in animal protein and animal fat, too rich in carbohydrates and too high in calories. It should be adjusted by reducing the amount of rice eaten, by substituting unpolished for polished rice and by increasing the amount of milk, milk-products, green leafy vegetables and fruits.

* From "Food" by McCarrison.

APPENDIX D.

Example of an average Diet used at the Kadwa Patidar Vidyarthi-Bhuvan, Ahmedabad.

Food Stuff.	Quantity in Ozs.	Proteins in grams.	Fats in grams.	Carbohydrates in grams.	Calories.
Wheat ...	7·26	28·33	3·92	147·84	741·03
Rice ...	5·09	11·52	0·42	111·74	495·99
Pulse ...	3·51	22·81	3·47	56·86	351·00
Ghee ...	1·14	0·00	26·33	0·00	237·12
Treacle ...	0·60	0·04	0·00	15·20	60·80
Oil ...	0·80	0·00	22·45	0·00	202·10
Milk ...	8·23	11·11	17·94	10·20	246·90
Vegetables ...	5·85	4·09	0·23	47·67	210·60
Sour Milk ...	0·20	1·70	0·20	0·27	2·04
Total ...	32·68	79·60	74·96	389·78	2547·58
Animal origin ...		13·00	44·27		
Less 10% for waste		7·96	7·49	38·97	254·75
Balance ...		71·64	67·47	350·81	2292·83

This diet contains 26% less in total proteins, 50% less in animal proteins, 21% less in total fats, 12% less in carbohydrates and 16% less in calories. (Vide p. 249).

To make it a well-balanced diet more of milk and milk products and green leafy vegetables should be taken.

(The figures given above were kindly supplied to me by my students Messrs. B. H. Patel and P. B. Patel to whom my sincere thanks are due.)

APPENDIX E.

Re: *Soya bean.**

The composition of 'Soya flour' and 'Soya milk' as compared with rice and wheat and milk is as follows:

	Soya Flour	Soya Milk	Milk	Wheat	Rice
Protein%	42·0	5·76	3·50	12·2	8·0
Fat%	20·0	2·46	3·50	1·7	2·0
Carbo-hydrates%	24·0	1·40	5·25	73·7	77·0
Water%	9·0	...	...	10·6	12·0
Calories	2·165	...	...	1750	1720
Ash	...	0·84	0·75	...	...

The ash of soya bean contains 6·12 per cent. of calcium and 28·66 per cent. of phosphoric acid.

* From a letter by Major-General Sir McCarrison.

APPENDIX F.

*Uses of the Soya-Bean.**

For very many centuries the cultivation of soya beans, both in China and Japan, has been of the greatest importance to those countries, where they are put to a variety of uses :—

(*a*) As a foodstuff they are made into :—

1. Bean sauce or soy, called in Japan "shoyu" (whence the name "soya") and in China, chiang-yu. It is made by boiling the beans adding an equal quantity of wheat or barley, and leaving the mass to ferment; a layer of salt and three times as much water as beans are afterwards put in, when the liquid is pressed and strained.
2. The Chinese paste chiang—not the same article of diet as the Japanese paste miso. It is made by farmers and eaten with fish, meat and vegetables, while the more expensive Chinese soy is only made by the well-to-do and restaurant keepers, and is not consumed by the poor.
3. Tou-fu, or beancurd, made from green or yellow beans, the former giving a better yield by being poorer in quality.

(*b*) The beans are also consumed as a table vegetable and in soups, and in Japan are used in confectionery.

(*c*) The oil is used as a substitute for lard in cooking. But even in these places, the centres of its origin, neither the soya bean itself nor the meal derived from it, has been used altogether as a staple article of food; it is the spices prepared from the soya bean which have found so extensive a use in these countries, and more especially in Japan, where they are eaten almost with every meal.

The flavour of the soya spice is obtained by injecting mildew fungus into the par-boiled beans, and leaving them in a moist condition at a temperature of from 20^{0} to 25^{0} centigrade, letting them ferment for months, even for years, before being used. It is then only that the savoury soya flavour is fully attained and made to render service as a popular article of food never found wanting in a Japanese household. Furthermore, many fermented products of the soya beans prepared in various ways, have long been consumed in the two countries such as "miso", the estimated average consumption of which in Japan alone may be stated at 40 grammes per head daily, "tofu", "natto" (two different kinds of cheese), as well as the soya milk and soya sauce. Of the latter Japan annually produces 700,000,000 litres of which every Japanese consumes on an average $\frac{1}{10}$ litre daily.

* This note was kindly prepared by Major-General Sir McCarrison who had advocated as early as 1927 in his evidence before the Royal Labour Commission the use of the Soya bean.

All these products are obtained by fermentation, thus improving their digestibility—which is not always characteristic of legumes—yielding an important supply of protein so necessary for human diet. The soya bean is one of the few seeds containing the three vitamins A, B, and D which are indispensable in a staple food consumed by mankind and necessary also in food for cattle.

The fat contents vary according to the various methods employed in extracting the oil, and arc said to average 6 per cent.

APPENDIX G.

*Uses of the Soya Bean**

It has been shown (J. H. Prentice, R. G. Baskett and G. S. Robertson) that the Soya bean plus mineral mixture bring about the beneficial effect on growth, maturity, egg production and mortality of chicks almost to the same extent as milk.

The Soya bean is rich in valuable nutritive ingredients *viz.*, proteins and fat. Starch is practically absent. It is also rich in mineral matter especially in soluble phosphates and potash.

It contains the ferment diastase in considerable quantities. It also contains uralytic ferment which is an important factor in physiological chemistry.

The biological value of the Soya bean protein is very high. It contains almost all the important amino-acids, particularly Glycine and tryptophane and lycine. In fact the protein of the Soya bean is very similar to that of cow's milk and animal muscles.

The Soya bean contains lecithin more than any other plant and therefore could be used for cure of nervous diseases. The lecithin of the Soya bean is, according to Dr. J. Freud, identical with that in egg yolk. The Soya bean contains three vitamins A. B. and D.

. . . .

The Soya bean crop is extensively grown in China and is used in various ways in human nutrition. The young pods are used as green vegetables ; seeds are used as vegetables. Sometimes they are allowed to sprout and sprouted grains make an excellent vegetable of high nutritive value. Their milk supply comes from Soya bean seeds which are soaked overnight in water and the juice of soaked seed is then pressed out. That is their milk, which tastes as cow's milk, is used for drinking in tea, for curds, butter milk, cheese etc.

In the course of human nutrition, especially amongst vegetarian India, the Soya bean is expected to play a very important part, if intro-

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* Extract from a letter from the Live-stock Expert to Government, Bombay Presidency, Poona.

duced. It can be used in the same way as other pulses, *e. g.*, as green vegetable (green seeds), dal, Bhajis, Sev, Papads and various other preparations. It can be allowed to sprout. Sprouted grains can make excellent vegetable. I can say that the Soya bean can be singled out as the best pulse so far known.

The best variety from the feeding point of view is one which contains the greatest fat percentage *viz.*, large yellow mammoth.

APPENDIX H.

It is gratifying to the author of this paper to note that a lecture given by him on "Dietetics: Food and Race" at Baroda on 7th October 1933, at which a State Officer in charge of Food Stuffs presided and in which the lecturer emphasised the high nutritive value of Soya bean as a food stuff, recommended its extensive use among the people and urged upon the State authorities the importance of growing it in their State, has led to the introduction of the Soya Bean cultivation in the Baroda territories. His Highness the Gaekwar of Baroda performed the ceremony of planting the Soya bean in January 1934.

That a Soya bean Restaurant was run in the H. O. H. Fete in Bombay where a number of preparations made from Soya bean were served augurs well for the future of this important food stuff.

APPENDIX I.

The progress made during the last few years in elucidating the composition and constitution of the three vitamins-A,-C and-D and the mastering of the technique employed in their commercial preparation is most remarkable.

The isolation of one full pound of pure crystalline ascorbic acid by Szent-Györgi from Hungarian capsicum (cayenne pepper), its identification with vitamin-C, the elucidation of its constitution by the Haworth school and its synthesis by Haworth and Hirst (4th August 1933) read like a fairy tale.

Vitamin-D is now commercially manufactured and costs one-eighth its price in cod-liver oil. This vitamin is most powerful in its activity—one part in two thousand millions exerts a recognisable effect on rat.

Unlike vitamins-C and-D, vitamin-A has not yet been prepared quite pure and in crystalline form.

The table* given below gives the composition of the three vitamins-A,-C and-D, their chemical nature, their daily human requirements, their physiological activity and the nature of their effect:

Compound.	Daily human requirement.	Dilution which gives detectable physiological effects.	Nature of effect.
Vitamin-A ($C_{20}H_{30}O$) and Carotene ($C_{40}H_{56}O$)	0.875 mgm. 1.400 mgm.	1 in 64×10^6. 1 in 32×10^6.	Growth "anti-infective. Maintenance of normal structure and function of mucous membranes.
Vitamin-C (Ascorbic acid) ($C_6H_8O_6$).	40 mgm. to 80 mgm.	1 in 1.4×10^6	"Anti-scorbutic". Maintenance of normal structure and function of blood capillaries.
Vitamin-D (Calciferol) ($C_{28}H_{44}O$)	0.25 mgm.	1 in 2240×10^6	Growth "anti-rachitic" or "calcifying" vitamin. Maintenance of normal structure of bones and teeth.

* "Biochemistry and the Manufacture of Fine Chemicals" by F. H. Carr. [J. S. C. I. (9-2-34) page 113.]

IMPORTANCE OF DIALYSIS IN THE STUDY OF COLLOIDS.

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Dialysis has been utilised since the time of Graham for freeing a colloidal solution from the impurities necessarily introduced into it at the time of its preparation, *viz.*, the peptising agent and the other electrolytes formed as a result of double decomposition. The importance of the influence of dialysis on the various properties of colloidal solutions has, however, not been generally realised by colloid chemists. In what follows (1) a summary of the results obtained in our laboratory on the variation of the different properties of some colloidal solutions on dialysing them to different extents is presented and (2) the views expressed in previous papers are considered from the point of view of changes in charge as observed by measuring the cataphoretic speed of colloidal solutions under varying conditions.

(a) Kinetics of coagulation.

2. According to Smoluchowski the rate of coagulation of a colloid in the sensitive range of electrolyte concentration is a simple reaction and the equation for rapid coagulation has the form

$$\theta = \frac{1}{K v_0} = \frac{1}{4\pi D r v_0}$$

where θ is the specific coagulation time, K the velocity constant, v_0 the number of particles at the beginning, r the radius of the sphere of attraction round each discharged particle and D the diffusion coefficient. He has distinguished slow coagulation from the rapid by the fact that in the former case all the encounters between the miscellae are not effective, but only a proportion which depends upon electrolyte concentration. Thus the expression for slow coagulation according to him will be

$$\theta_1 = \frac{1}{K_1 v_0} = \frac{1}{8\pi D r v_0 x}$$

where x is the fraction by which K, the velocity constant for rapid coagulation, must be multiplied. If this theory is correct, one should be able to pass from a coagulation velocity curve of rapid coagulation to one of slow coagulation at a lower electrolyte concentration by multiplying the time t by a certain numerical factor, *i. e.*, the curves of

coagulation velocity must be related to one another. Several workers have found that the view of v. Smoluchowski is correct (for references see Desai, Trans. Faraday Soc., 24, 181, 1928; Patel and Desai, *ibid.*, 26, 128, 1930; Desai, Kolloidchem. Beih., 26, 357, 1928).

3. It has however been shown by other investigators (for references see papers of Desai quoted in Para. 2) that the rate of coagulation of a colloid over the sensitive range of electrolyte concentration is not a simple reaction as postulated by v. Smoluchowski and that the rate of slow coagulation has an auto-catalytic character and the reaction velocity can be represented by an equation of the form

$$\frac{dx}{dt} = \mathrm{K}\,(1+bx)\,(1-x)$$

where K and b are constants and x the amount of change in time t.

4. The widespread opinion, first put forward by Hardy (Proc. Roy. Soc., 66, 110, 1900) that coagulation begins only when colloidal particles are completely discharged and the iso-electric point is reached, has been found to be erroneous by Powis (Zeit. f. physik. Chemie, 89, 186, 1915). According to him coagulation begins as soon as the electro-kinetic potential or the electric charge falls below a certain absolute value. This value of the electro-kinetic potential, at which coagulation first begins, has been termed by Freundlich the "first critical potential" and is said to have the same characteristic value for any particular sol when coagulated with salts having coagulating ions of different valencies. The experiments of Burton (Phil. Mag., 17, 583, 1909), Kruyt Roodvoets and van der Willigen (Fourth Colloid Symposium, 1926, pp. 304-310) and Kruyt and van der Willigen (Z. physikal Chem., 130, 170, 1927) have shown that their results also support Powis' theory of critical potential.

5. Freundlich (Colloid and Capillary Chemistry Eng. Translation—1926, pp. 431-447) has utilised the existence of the first critical potential to explain the phenomenon of slow coagulation. According to him slow coagulation begins when the first critical potential value is reached. The slow coagulation passes into rapid coagulation when the value of the potential difference becomes zero or the iso-electric point is reached (Freundlich's second critical potential). In the region of slow coagulation as the particles are still charged, only those collisions are successful in bringing about coalescence in which the velocity of the particles exceeds a certain value. After the iso-electric point is reached all the collisions will be successful although the velocity with which the particles move might be very small in some cases, because there will be no repulsive forces between the particles.

6. Recently Mukherjee and co-workers (J. Indian Chem. Soc., 4 493, 1927; 5,697, 1928; Nature, 122, 960, 1928; Special Number of the Journal of the Indian Chemical Soc., 1933, p. 201) have expressed

doubts about the existence of critical potential characteristic of coagulation of a colloid by electrolytes. It should be stated that their conclusion is based on results most of which have been taken with mixtures of electrolytes and non-electrolytes as well as with electrolytes containing organic anions and much credence cannot be given to their conclusions. The charge on colloidal particles of a sol can be varied by changing the amount of the peptising agent in the sol. In our laboratory we have prepared colloidal solutions of ferric hydroxide and thorium hydroxide having different initial charge on the particles by dialysing the sols to different extents and studied coagulation in the presence of HCl, H_2SO_4,KCl, K_2SO_4, $MgCl_2$ and $MgSO_4$. Details of these measurements will be published in due course (B. N. Desai and S. K. Borkar on Ferric Hydroxide and B. N. Desai and A. K. Desai on Thorium Hydroxide). In the case of colloidal ferric hydroxide, the sol begins to coagulate in all the cases when the cataphoretic speed of colloidal particles is reduced to 25–29 although the two samples of the sol tried had different initial cataphoretic speeds—38 and 54. Similarly the two samples of thorium hydroxide sol having initial cataphoretic speed of 33 and 25 begin to coagulate when the cataphoretic speed of the particles is reduced to 19–21 in the former and 16–17 in the latter case. Differences in the value of the critical charge in individual cases can be easily understood if the preferential adsorption (the word preferential indicating that the ion is adsorbed in the inner sheet of the double layer) of similarly charged ions is considered as suggested by Desai (J. Bombay University, 1, Part II, 25, 1932). The idea of critical potential is thus completely supported by our measurements.

It should be pointed out here that generally it is observed that the value of the cataphoretic speed at which coagulation begins is somewhat higher in those cases where there is a marked preferential adsorption of the similarly charged ions. Why this is so is not quite clear. Some experiments are being undertaken for getting a clear idea of this point.

7. In our papers referred to in para. 2 it has been shown that in the case of colloidal thorium hydroxide the appearance of the S-shaped coagulation velocity (C. V.) curves or demonstration of the autocatalytic nature of the coagulation process depends on

(i) the suitability of the method employed in following the course coagulation,

(ii) the concentration of the coagulator,

(iii) the purity of the sol (this can be changed by dialysing the sol), and

(iv) the concentration of the disperse phase. The causes which might be responsible for the non-observance of auto-catalysis due to

factor (i) (suitability of method) have been discussed in detail in our papers.

(ii) Concentration of the coagulator.—As stated in para. 5 slow coagulation begins when the charge is lowered to the critical value (first critical potential) and the slow coagulation passes into rapid coagulation when the iso-electric point (second critical potential) is reached. In the case of concentrated electrolytes the time required to pass from the first critical potential to the second will be very small (in seconds) and therefore with the limitations of the present methods of following the course of coagulation, it will be very difficult to get the S-shape of the C. V. curves. This however will not be the case with dilute electrolytes where the potential difference decreases slowly and the region of slow coagulation extends over some minutes (cf. Powis, loc. cit.), and hence the appearance of the S-shaped C. V. curves. It should however be stated that the C. V. curves are not found to be S-shaped even with dilute electrolytes having multivalent coagulating ions. We have observed that the amount of bivalent coagulating ion required to lower the charge to the critical value is much less than that of univalent coagulating ion. This is due to greater preferential adsorption of the former ions. As a result even with dilute electrolytes containing multivalent coagulating ions if the potential of the double layer is lowered at all, the rate of its lowering will be great in the beginning and hence the rate of coalescence also will be large. At very great dilutions, the coagulation will not proceed far as there is not sufficient electroyte left to lower the potential difference any further. The coagulation will therefore be partial in these cases. In fact cataphoretic experiments showed that in such cases a greater amount of uncoagulated sol was still left in the mixture. In those cases where there is complete coagulation *i. e.*, with somewhat concentrated electrolytes having multivalent coagulating ions, the time required to pass from the critical value to the iso-electric point will be very small (in seconds) and therefore it will be impossible to observe the slow coagulation phenomenon as in the case of concentrated electrolytes having univalent coagulating ions.

(iii) Purity of the sol.—In explaining the effect of this factor it was assumed by us (Patel and Desai, loc. cit.) as done by other workers that the charge on the colloidal particles in the case of thorium hydroxide also decreases continuously with the progress of dialysis. It was argued that as the initial slow coagulation refers only to the process which takes place between the region of the first and second critical potentials, if by any means the time required to pass from the first to the second critical potential is made appreciably small or negligible, the initial and less steep portion of the C. V. curves will also disappear. Continuous lowering of charge with the progress of dialy-

sis will help to achieve this purpose and hence for very pure sols the C.V. curves will not be S-shaped. Even with a dilute electrolyte concentration in the case of very pure sols, the C. V. curves will not be S-shaped because the value of the charge being very near the iso-electric point, the time required for coagulation will be very small. Actual measurements of charge in the case of this sol have however shown that with the progress of dialysis the cataphoretic speed first increases, reaches a maximum value and then decreases continuously (Desai, Current Science, 1, 38. 1932; 1, 125, 1932; also paper by B. N. Desai and A. K. Desai, loc. cit.). The above line of argument therefore cannot be applied to the period of dialysis when the cataphoretic speed continuously increases with the progress of dialysis, as the charge on the colloidal particles will be removed further and further away from the first or the second critical charge. The C. V. curves were found to be S-shaped in the case of sols dialysed for about eight days while for sols dialysed for longer periods (about 14 days) no S-shaped C. V. curves could be obtained (Patel and Desai, loc. cit.). As found in the later investigation (B. N. Desai and A. K. Desai, loc. cit.) the cataphoretic speed increases with the progress of dialysis up to a period of only about 5 days (the rate of dialysis being almost the same in the two cases) and therefore the cataphoretic speed being regularly decreasing with progress of dialysis after eight days, the previous arguments used for explaining the non-observance of S-shaped C. V. curves for sols dialysed for long periods (very pure sols) still hold good.

(iv) Concentration of the disperse phase.—It was observed by us (Patel and Desai, loc. cit.) that when thorium hydroxide sol is coagulated by an electrolyte of the same concentration throughout, the tendency of the C. V. curves to be S-shaped becomes less and less with an increase in the dilution of the sol. This was explained by assuming that in the case of a dilute sol a particular amount of electrolyte will bring down the charge on the particles more nearly to the critical point or the iso-electric point than in the case of a concentrated sol. This will mean that the time required to reach the iso-electric point after adding the electrolyte to the sol will be less with a dilute sol than with a concentrated sol. With the progress of dialysis as the charge on the particles is brought nearer and nearer to the iso-electric point, the time required for coagulation will be so small with the dilute sol when compared with the concentrated one—the same amount of electrolyte having been added in both the cases—that the C. V. curves may not be S-shaped at all. This effect will be more marked in the case of a sol dialysed for longer periods than one dialysed for shorter periods. Now as stated before the charge on colloidal particles of thorium hydroxide increases in the initial stages of dialysis and therefore the ideas modified under

factor (iii) in the preceding sub-para. should only be applied. Also our later measurements (B. N. Deasi and A. K. Desai, loc. cit.) have shown that for samples of this sol dialysed for periods shorter than what corresponds to the maximum in the cataphoretic speed dialysis curve, on diluting the sol, the cataphoretic speed first increases, reaches a maximum value and then decreases ; on the other hand, for sols dialysed for longer periods, on diluting the sol, the cataphoretic speed continuously decreases. In view of the evidence of the charge measurements, the previous explanations do not hold good only for those cases in which the cataphoretic speed increases upto a certain dilution. There is however one additional factor which has not been hitherto considered in explaining this influence, namely, the effect of concentration of the disperse phase on the size of the particles. Desai (in paper referred to in para. 2) has shown that the auto-catalytic nature of the coagulation process and the S-shaped C. V. curves may not be observed at all with dilute sols. These can best be observed in fairly concentrated sols which contain a considerably larger number of particles because sufficiently large multiple particles can be formed in them. It is considered that this factor will have a considerable effect on the nature of the C. V. curves.

8. In a recent paper S. S. Joshi and V. L. Narayan (Special Number of the Journal of the Indian Chemical Soc., 1933, p. 41) have studied in detail the influence of wall area in the coagulation of colloidal solutions of MnO_2, Sb_2S_3 and positively charged Fe_2O_3. They have observed that the rate of coagulation is markedly increased in all cases when the wall area of the coagulating system is increased by introducing glass beads. They also find that when the same number of beads and the containing walls are paraffined the coagulation is sensibly retarded in all cases. In the light of their results they consider unlikely that the increase in the rate of coagulation, under wall effect alone, can convert a 'slow' into a 'rapid' coagulation. They conclude that autocatalysis cannot be considered as a general characteristic of coagulation as has been supposed by some workers, but that it is a secondary process which adds to the main course of coagulation under certain conditions.

Now as shown by electrosmotic, cataphoretic and stream-potentials measurements, the wall-layer of glass in contact with water becomes negatively charged. The nature of this charge will be modified considerably in the presence of electrolytes as well as when the glass surface is paraffined. It is therefore certain that the glass surface will help or retard the coagulation according to the nature of charge on it and on the colloidal particles. Moreover glass walls themselves, whether paraffined or not and whether charged or uncharged, will act as centres for coalescence. In view of these considerations it is not

justifiable to say that the results of Joshi and Narayan (loc. cit.) support the conclusion that the nature of coagulation process is not intrinsically auto-catalytic.

On the other hand, their results can well be utilised to show that the nature of coagulation process is auto-catalytic. For as shown by them the walls of the containing vessel (unparaffined) make the S-shape of the C. V. curves less marked and it is quite likely that the non-observance of auto-catalysis by some workers might be to a certain extent due to this effect.

9. In the light of the foregoing evidence it can be stated that as yet no investigator has succeeded in showing that the nature of the coagulation process is not intrinsically auto-catalytic. Failure to observe the S-shape of the C. V. curves and the auto-catalytic nature of the coagulation process can be due to several factors which have been considered in this section and which as shown will considerably modify the nature of the C. V. curves and of coagulation. Also as shown in this section the idea of critical potential is completely supported; if any deviations occur they can be explained by taking the influence of the similarly charged ions into consideration.

(b) *Applicability of Schulze-Hardy law.*

10. It has been shown by Desai (Kolloidchem. Beihefte, 26, 384, 1928) that in the case of colloidal thorium hydroxide containing appreciable amounts of HCl, the C. V. curves for equivalent concentrations of different electrolytes having the same coagulating ion (univalent) are not identical and that the C. V. is not the same in different cases. This is in contradiction to the requirements of the Schulze-Hardy law according to which the time required for the coagulation of a sol by electrolytes having the same oppositely charged ion is independent of the nature of that ion of the coagulator which carries the same charge as the colloidal particles. It has been expressed by several investigators (references are given in the above paper of Desai on p. 394) that unless and until the influence of the similarly charged ion is taken into consideration, no theory will be adequate enough to explain the results of coagulation of sols by electrolytes. In the case of multivalent coagulating ions the influence of the similarly charged ion being negligible, the Schulze-Hardy law is obeyed. It has also been shown by Desai (loc. cit.) that the applicability of the Schulze-Hardy law increases with the progress of dialysis. This has been explained by assuming that with the progress of dialysis the preferential adsorption of the similarly charged ions decreases.

11. The measurements of cataphoretic speed of colloidal solutions of ferric hydroxide (Desai and Borkar, loc. cit.) and of thorium hydroxide (B. N. Desai, and A. K. Desai, loc. cit.) in the presence

of varying amounts of electrolytes have shown that preferential adsorption of similarly charged ions takes place in the presence of small amounts of electrolytes containing monovalent coagulating ion, while with bivalent coagulating ion no preferential adsorption of similarly charged ions is allowed to take place. It has also been observed that the amounts of different electrolytes necessary to lower the value of the charge to the critical value are not the same. The earlier conclusions are thus supported by the evidence of charge measurements in these respects. The charge measurements, however, show that the preferential adsorption of similarly charged ions does not appreciably decrease with the progress of dialysis *i. e.*, with an increase in the purity of the sol. Therefore the explanation advanced in the previous paragraph about applicability of the Schulze-Hardy law with the progress of dialysis requires modification. In the case of thorium hydroxide the deviations from the Schulze-Hardy law only disappear after a period of dialysis of 10 days or so. During this period of dialysis the charge on the colloidal particles will be brought nearer and nearer to the iso-electric point (the maximum cataphoretic speed having occurred at a period of dialysis of 5 days or so) and thus as shown in section (a), coagulation tends to be rapid in all the cases (disappearance of S-shaped nature of the C. V. curves). Under the circumstances it is quite likely that although different similarly charged ions may be preferentially adsorbed to different extents in the beginning, this may not affect the nature of the C. V. curves to any appreciable extent.

12. In view of the evidence of charge measurements it is also considered that the mechanism of coagulation as pictured by Weiser (J. Phys. Chem., 28, 232. 1924; 29, 955, 1925) and Dhar (ibid., 28, 457, 1924) for explaining the preferential adsorption of similarly charged ions is difficult to understand. For, the preferential adsorption of the similarly charged ions is noticed only in the presence of small amounts of electrolytes and at these concentrations the colloidal solutions do not show at all any tendency for coagulation.

(c) Relation between charge and stability.

13. Numerous papers have been published by investigators in Colloid Chemistry on the stability of various colloidal solutions in the presence of electrolytes---greater floculation value (F. V.) greater stability and smaller F. V. smaller stability. These investigations have been made with colloidal solutions which have been purified to certain extent by dialysis. The decrease in the F. V. with the progress of dialysis has been explained generally by assuming that with the progress of dialysis, the charge on the colloidal particles continuously decreases. We have measured cataphoretic speed and stability simultaneously of colloidal solutions of gold, ferric hydroxide and thorium

hydroxide with the progress of dialysis. The following results have been obtained (for details refer to papers by Desai, Nabar and Barve, J. Indian Chem. Soc., 9, 463, 1932; Desai and Borkar, loc. cit. B. N. Desai, loc. cit.):—

(*i*) In the case of colloidal gold, with the progress of dialysis both cataphoretic speed and stability as determined by F. V. increase in the beginning, reach a maximum value and begin to decrease simultaneously thereafter.

(*ii*) The cataphoretic speed of colloidal particles of ferric and thorium hydroxide, first increases, reaches a maximum value and then decreases on subjecting the sols to dialysis; the F. V., on the other hand, continuously decreases with the progress of dialysis in both the cases.

14. The above results show that although there is a direct relation between charge and stability in the case of colloidal gold, the same is not found to be the case with colloidal ferric and thorium hydroxide. In the latter case such relation is only found to exist for the period of dialysis when both cataphoretic speed and F. V. decrease regularly. The reasons for a regular decrease in the F. V. with the progress of dialysis, in spite of first an increase and then a decrease in the cataphoretic speed, have also been advanced by us. In both the cases—ferric as well as thorium hydroxide—an increase in the preferential adsorption of the stabilising ions in the presence of KCl (electrolyte added for F. V. determinations) as well as a change in the size of the particles during dialysis have been found to be very significant from the point of view of stability. In the case of ferric hydroxide the changes in the hydration of colloidal particles in the initial stage of dialysis are also partly responsible for the abnormal behaviour.

15. It has been observed by us that on adding small increasing amounts of KOH in the case of gold sol, of HCl and $FeCl_3$ in the case of ferric hydroxide sol and of HCl in the case of thorium hydroxide sol, the cataphoretic speed first increases and then decreases or that there is a maximum in the cataphoretic speed (C. S.)—concentration (C) curve. The initial increase in the cataphoretic speed is due to a preferential adsorption of the similarly charged ions. All these sols initially contain an amount of the stabilising electrolyte which is appreciably more than what correspondns to the maximum in the C.S.—C curve for that electrolyte. With the progress of dialysis, the amount of the stabilising agent continuously decreases. The process of dialysis can therefore be considered as a reverse of the process of adding small increasing amounts of the peptising electrolyte to the colloid in so far as the removal of the peptising electrolyte is concerned; one should thus expect that with the progress of dialysis the cataphoretic speed will first increase and then decrease. Thus a col-

loidal solution when subjected to dialysis will show (*a*) first an increase and then a decrease or (*b*) a continuous decrease of the cataphoretic speed according as it initially contains an amount of the peptising agent (*a*) more than or (*b*) equal to or less than what corresponds to the maximum in the C.S.—C curve with that electrolyte. Other sols are being investigated from this point of view.

16. From the foregoing it will appear that it is not safe to draw conclusions about changes in charge from the stability determinations as has hitherto been the practice, for although this may serve a useful criterion in some cases it may not do so in others.

(d) Changes in cataphoretic speed and stability of colloidal solutions of ferric and thorium hydroxide dialysed and diluted to different extents.

17. We have observed (Desai and Borkar, loc. cit.; B. N. Desai and A. K. Desai, loc. cit.) that (i) for samples of sol dialysed for periods shorter than what corresponds to the maximum in the C. S.—D (dialysis) curve, on diluting the sol, the cataphoretic speed of colloidal particles first increases, reaches a maximum value and then decreases and (ii) for samples of sol dialysed for longer periods, the cataphoretic speed regularly decreases on dilution of both the sols.

18. Both on diluting and dialysing the sol the amount of the peptising electrolyte decreases. The processes of dilution and dialysis can therefore be considered similar in this respect. Now as shown in section (c), if a colloidal solution initially contains an amount of the peptising electrolyte more than what corresponds to the maximum in the C. S.—C curve the cataphoretic speed first increases and then decreases on dialysis. The samples of the sol dialysed for periods shorter than what correspond to maximum in the C. S.—D curve do contain an amount of the peptising electrolyte which will be more than what corresponds to the maximum in the C. S.—C curve and therefore the processes of dilution and dialysis being similar, the cataphoretic speed should first increase and then decrease on dilution of the sol. Sols dialysed for longer periods than what corresponds to the maximum in the C. S. —D curve should show on diluting, a continuous decrease in the cataphoretic speed as they contain an amount of the peptising electrolyte less than what corresponds to the maximum in the C. S.—C curve; for such samples the cataphoretic speed also regularly decreases on dialysis.

19. If the analogy between processes of dialysis and dilution given in the preceding paragraph is correct, one should expect that the maximum in the C.S.—Dil. (dilution) curve should occur at lower dilutions in the case of sols dialysed for longer periods than those dialysed for shorter periods. This has actually been found to be the

case (Desai and Borkar, loc. cit. and B. N. Desai and A. K. Desai, loc. cit.). In what respects dialysis and dilution cannot be considered similar has also been discussed by Desai in the above papers. It is however considered that changes in cataphoretic speed on dialysis and dilution are mostly due to changes in the concentration of the peptising electrolyte. Different sols are being investigated to see how far observations (i) and (ii) given in para. 17 are also noticed in them in order to find out if this behaviour is a general property of colloidal solutions.

20. On diluting the sol the stability as determined by the F.V. with KCl decreases regularly for both ferric and thorium hydroxide sols. As shown in para. 16 there does not appear a direct relation between charge and stability in all the cases; for, as stated above, the changes in the cataphoretic speed on dilution are not the same for sols dialysed for different periods.

21. Dhar (for references see Desai, Kolloidchem. Beihefte, 26, 385, 1928) has divided colloidal solutions into two divisions according as they show normal or abnormal behaviour to the dilution rule, *viz.*, the greater the concentration of a colloid the greater the amount of an electrolyte necessary for coagulation. According to Dhar, only those sols show an abnormal behaviour to dilution rule which show appreciable preferential absorption of similarly charged ions from the solution. Desai (above quoted paper) has however shown that colloidal thorium hydroxide can be made to show either normal or abnormal behaviour to dilution rule by varying the purity of the sol (by subjecting the sol to dialysis), and that it is erroneous to divide the colloidal solutions into two classes as done by Dhar. We have also observed that both colloidal ferric and thorium hydroxide show appreciable preferential adsorption of K ion in the presence of KCl (Desai and Borkar, loc. cit; B. N. Desai, and A. K. Desai, loc. cit.), and that both these sols show normal behaviour to dilution rule when they are coagulated with KCl. Thus Dhar's explanation about abnormal behaviour to dilution rule also does not seem to be correct.

22. In explaining the abnormal behaviour to the dilution rule, it has also been stated that a dilute sol adsorbs proportionally more of the similarly charged ion than the concentrated one. Our preliminary results (Desai and Barve, Nature, 128, 907, 1931) have shown that on the addition of small increasing amounts of KCl and $MgCl_2$, the cataphoretic speed first increases and then decreases, the initial increase being greater with the concentrated sol than with the dilute sol. It was also observed that the maximum value of cataphoretic speed occurs at a lower concentration of the electrolyte in the case of dilute sol than the concentrated one. These results thus do not support the conclusion that there being greater adsorption of the similarly charged ion in a dilute sol than a concentrated one, the charge will be greater in the

former case and hence a greater amount of electrolyte will be required for coagulation. Also the explanation for disappearance of abnormality to the dilution rule, as in the case of the Schulze-Hardy law, with the progress of dialysis should be modified as indicated in para. 11. It appears that increase in distance between colloidal particles on dilution, might have considerable influence on the coagulation and make the sol show an abnormal behaviour as regards stability (cf. Desai, Kolloidchem. Beihefte, 26, pp. 400–401, 1928).

(e) *Relation between charge and viscosity.*

23. There are two different views at present about relation between charge and viscosity. According to v. Smoluchowski (for references on this subject see papers by Desai and Borkar, loc. cit.; B.N. Desai and A.K. Desai, loc. cit.) the movement of electrically charged particles of a sol causes the development of an electric field, which hinders the flow of the sol resulting in an increase of its viscosity. This conclusion was found to be supported by Smoluchowski's measurements which showed that a sol containing particles of greater electric charge was more viscous than a sample containing particles of feeble electric charge. On the other hand, Dhar and co-workers from their measurements with a number of sols have tried to show that the view of Smoluchowski is untenable. According to them, other things being identical, a decrease in the electric charge on colloidal particles causes an increase in hydration and necessarily in the viscosity of the sol. It should however be stated that Dhar's conclusions about changes in charge are based on F.V. determinations and this is certainly not correct in view of what has been said in the foregoing sections about relation between charge and stability as determined by F.V.

24. We have made simultaneous measurements of charge and viscosity of colloidal solutions of ferric and thorium hydroxide dialysed to different extents and of different concentrations and in the presence of varying amounts of electrolytes. In the case of colloidal ferric hydroxide we have observed (Desai and Borkar, loc. cit.) that

(i) With the progress of dialysis, cataphoretic speed first increases and then decreases, while viscosity first decreases and then increases. The maximum in the C.S.—D curve and the minimum in the V (viscosity)—D curve however do not occur at the same stage of dialysis.

(ii) On adding small increasing amounts of electrolytes with univalent coagulating ion, cataphoretic speed first increases and then decreases, while viscosity first decreases and then increases. The maximum in the C.S.—C curve and the minimum in the V—C curve do not however occur at the same concentration of the electrolyte.

(iii) With highly concentrated sols of Fe_2O_3 the initial decrease

in viscosity with the progress of dialysis is not noticed at all (Desai, Special Number of the Journ. Indian Chem. Soc. p. 37, 1933).

In the case of colloidal thorium hydroxide we have observed (B.N. Desai and A.K. Desai, loc. cit.) that

(i) With the progress of dialysis, cataphoretic speed first increases and then decreases, while viscosity continuously increases—the increase being more marked in the later stages of dialysis.

(ii) On diluting the sol cataphoretic speed first increases and then decreases for samples which have been dialysed for periods shorter than what corresponds to the maximum in the C.S.—D curve and it continuously decreases on dilution for samples which have been dialysed for longer periods. Viseosity, on the other hand, continuously decreases on dilution in all the cases although the samples of sol were dialysed to different extents. Also the percentage increase of viscosity on dialysis is greater in the case of concentrated sols than dilute sols.

(iii) For all the samples of the sol, whether dialysed for short or long periods, cataphoretic speed first increases and then decreases on the addition of small increasing amounts of electrolytes having univalent coagulating ion, the initial increase in cataphoretic speed being not noticeable with electrolytes having bivalent coagulating ion. Viscosity, on the other hand, increases continuously with all the electrolytes for samples of the sol which have been dialysed for periods shorter than what corresponds to the maximum in the C.S.—D curve, while for samples dialysed for longer periods the viscosity first decreases and then increases on adding small increasing amounts of electrolytes to the sol.

25. It will appear from the above results that neither the view of Dhar nor of v. Smoluchowski can alone explain the changes in charge and viscosity of colloidal ferric and thorium hydroxide under different conditions—with the progress of dialysis, with a change in dilution and when small increasing amounts of different electrolytes are added. As pointed out in our papers one has to consider the effect of various factors, which are given below, in explaining these changes in charge and viscosity.

(i) Changes in the concentration of disperse phase.—The viscosity of the sol will generally decrease with a decrease in the concentration of the disperse phase.

(ii) Electro-viscous effect.—The viscosity of the sol will increase with an increase in the cataphoretic speed of colloidal particles and decrease when the cataphoretic speed decreases.

(iii) Changes in hydration of colloidal particles.—With an increase in hydration of the colloidal particles (this tendency is most pronounced with the progress of dialysis when the sol shows a tendency to set to gel) the viscosity will also increase, there being an increase in

the effective volume of the particles. On diluting the sol, the hydration of colloidal particles may increase and the viscosity may also increase due to an increase in the effective volume of the particles.

(iv) Variation in the shape and structure of particles.—As for the variation of the shape of the particles little is known. However the structure of the particles is sure to vary both during dialysis and dilution. During dialysis, there is a tendency for the particles to aggregate as during coalescence and thus increase their effective volume and the viscosity. On the other hand, on dilution the larger aggregates may break up into smaller ones and thus decrease the effective volume of the particles as well as viscosity.

(v) Changes in the concentration of the electrolyte.—The viscosity will increase regularly with an increase in the concentration of the electrolyte present in the sol except with those electrolytes which show a negative viscosity within a particular range of concentration.

26. In a previous paper Desai (Kolloidchem. Beihefte, 26, 422, 1928) has explained changes in viscosity on dialysis and ageing by assuming that as with the progress of dialysis and on ageing, the sol becomes unstable, the charge decreases and therefore viscosity increases. In view of what has been said in previous sections it is not right to draw conclusions about changes in charge from stability determinations and therefore the above explanation may have to be considerably modified. The influence of all the factors mentioned in the previous para. should be taken into account. As the ceric hydroxide sol initially contains quite a large amount of the peptising electrolyte it is likely that on dialysing, the charge on colloidal particles may first increase and then decrease as in the case of ferric hydroxide and thorium hydroxide sols. The changes in the various properties of colloidal particles of ceric hydroxide under different conditions are being investigated.

27. In a recent paper Ghosh and Banerji, (Bul. Acad. Sci. U. P., 2, 135, 1933) have given some measurements of viscosity of colloidal ferric phosphate dialysed and diluted to different extents, the flow of the liquid being caused under varying pressure. They have stated that if measurements of rates of flow of a colloid be undertaken at fairly high pressures, the change in the viscosity of colloids with the progress of dialysis will be either nil or insignificant. According to them hydration has to be assumed to be very labile. Our results of study (Desai, loc. cit.) of the ceric hydroxide sol and gel also seem to support the conclusion about labile nature of hydration. Ghosh and Banerji however believe that colloidal solutions show a high viscosity due to an orientation of the particles rather than due to high hydration of the disperse phase. According to them the tendency to orientation increases as the electric charge on the colloid particles is decreased and

as, during dialysis, the electric charge on colloidal particles continuously decreases the viscosity will increase. It should be pointed out here that their conclusion about changes in charge during dialysis is based on coagulation experiments as they themselves state. This is not justified in view of what has been stated in previous sections about changes in charge during dialysis. In fact the ferric phosphate sol which they have used initially contained a considerable amount of the peptising agent and therefore the charge on colloidal particles during dialysis will first increase and then decrease instead of continuously decreasing as shown by stability determinations. Our examination of ceric hydroxide gel under ultra-microscope (Desai, loc. cit.) has revealed no tendency for a definite orientation of the particles in that gel. Our gel contained more than 2000 mols. of water per one mol. of CeO_2 (the amount of water depending on temperature of gel formation) and it is considered that a considerable increase in viscosity during dialysis is due to an increase in hydration of the particles. Also the decrease in viscosity under high pressures noticed by Ghosh and Banerji (loc. cit.) is not due to a destruction of the orientation of colloidal particles under high pressures as supposed by them, but definitely due to a decrease in the hydration of the particles on account of some water molecules wrapping the particles having been torn off and the effective volume of the particles having thus been decreased. It is not necessary to consider that increase in hydration is as a result of adsorption of water by colloidal particles, for large amount of water held by the gel will demand adsorption several molecules deep and this is incompatible with Langmuir's theory (J. Amer. Chem. Soc., 38, 2221, 1916 ; 40. 1361, 1918), according to which the adsorbed layer cannot be several molecules deep. The picture of hydration suggested by Desai (Kolloidchem. Beihefte, 26. 434, 1928) will easily allow some water molecules being torn off under high pressures and thus explain the decrease in viscosity with an increase in the shearing force. There is also no evidence to suppose that orientation of colloidal particles in a sol changes during dialysis.

28. In view of what has been stated in this section it will be clear that it is erroneous to draw conclusion about changes in charge from changes in viscosity as in the case of stability (para. 16), and that there is a necessity to study simultaneously changes in charge and viscosity of colloidal solutions under different conditions. This is being done in our laboratory.

(*f*) *Sensitisation of colloidal solutions by non-electrolytes.*

29. We (Patel and Desai, Kolloid Zeit., 51, 318, 1930) have studied the influence of non-electrolytes—methyl, ethyl and iso-propyl alcohols, acetone, urea and cane-sugar on the rate of coagulation of

colloidal thorium hydroxide of different degrees of purity in the presence of NaCl; the coagulation of the sol in the presence of non-electrolytes alone has also been studied. The following results have been obtained:—

(i) With the progress of dialysis the sol is more and more sensitised by non-electrolytes.

(ii) A fairly pure sample of the sol (sol dialysed for 6, 8 and 11 days) could be coagulated by non-electrolytes alone, the coagulating power of non-electrolytes increasing with an increase in the purity of the sol.

(iii) The C. V. curves for lower concentrations of electrolytes and non-electrolytes or non-electrolytes alone are found to be S-shaped The S-shape of the C. V. curves becomes less marked with an increase in the purity of the sol.

(iv) The order of effectiveness in sensitisation or coagulation of the sol by the non-electrolytes tried in these experiments is

Urea>methyl alcohol>ethyl alcohol>iso propyl alcohol>cane-sugar >acetone.

30. The view of Weiser (J. Phys. Chem., 28, 1253, 1924) that sensitisation is caused due to the cutting down of the adsorption of the coagulating ion in the presence of non-electrolytes is not applicable in the present case because the C. V. increases in the presence of non-eloctrolytes. Also the fact that fairly pure samples of the sol could be coagulated with non-electrolytes alone shows that the above view is not of much help in explaining our results.

31. The other view of Weiser (loc. cit.) that the non-electroytes displace the stabilising ion is supported by our results. For, such a displacement of the stabilising ion will make the sol unstable and if stability is defined in terms of coagulation concentration, smaller amounts of eletcrolytes will be required to coagulate the sol in the presence of non-electrolytes. This view will also explain the coagulation of the sol by non-electrolytes alone, for if the non-electrolytes are able to displace so much amount of the stabilising ion from the inner sheet of the double layer that the value of the charge on the particles is lowered to the critical value, the sol will begin to coagulate—slow coagulation phenomenon. If the amount of the stabilising ion displaced is quite considerable the value of the charge on the colloidal particles may be brought down to the iso-electric point and the coagulation may become rapid from the beginning. It should however be stated that it is not possible to say how far the displacement of the stabilising ion by the non-electrolytes will be shown by actual adsorption experiments.

32. The suggestion of Wo. Ostwald (Grundriss der Kolloid Chemie, 1 Aufl. 1909. p. 441) and of Freundlich (Colloid and Capillary

Chemistry. Eng. Translation, 1926, pp. 462-65) that changes in the dielectric constant decide the influence of non-electrolytes is found to be supported by these experiments. All the non-electrolytes tried in our measurements had dielectric constant lower than that of water and therefore if the non-electrolytes are adsorbed in the double layer the dielectric constant will be lowered and with it the electric charge on the colloidal particles. Whether there will be slow or rapid coagulation in the beginning will depend upon the extent of the lowering of the charge.

We have observed that with the progress of dialysis the charge on colloidal particles of thorium hydroxide first increases and then decreases. If the coagulation by non-electrolytes is due to a lowering of the dielectric constant and hence of the electric charge, one would expect that the samples of the sol having the same cataphoretic speed *i. e.*, on the one or the other side of the maximum in the C. S.–D curve should show the same behaviour when non-electrolytes are added. It will however be seen from our results that the sol could be coagulated with non-electrolytes alone only when it was dialysed for long periods (6, 8 and 11 days); sols dialysed for shorter periods *i. e.*, less than what corresponds to the maximum in the C. S.–D curve (sols dialysed for 0 day and 3 days) could be only sensitised but not coagulated by non-electrolytes alone. It thus appears that the non-electrolytes are not able to lower the dielectric constant as much in the presence of appreciable amounts of electrolyte (sols dialysed for 0 day and 3 days certainly contain quite appreciable amounts of the stabilising electrolyte when compared with samples dialysed for 6, 8 and 11 days) as they can do in their absence, or that the adsorption of the non-electrolytes in the presence of electrolytes is not quite appreciable. A tendency to this effect is noticeable somewhat in the results of Mukherjee, Rai Choudhuri and Rao (J. Indian Chem. Soc., 5, 697, 1928). This point however requires further investigation.

The results of Mukherjee and co-workers (loc. cit.) show that the cataphoretic speed of colloidal particles of arsenious sulphide is lowered more and more on adding larger and larger amounts of non-electrolytes which also sensitise the sol. It is therefore quite likely that even in the case of thorium hydroxide addition of non-electrolytes which sensitise the sol will lower the cataphoretic speed. This work is in progress.

33. Mukherjee and co-workers (loc. cit.; J. Indian Chem. Soc., 2, 307, 1925; 3, 349, 1926) consider that the diminution in the dielectric constant brings about two effects :—

(i) The electrical work, resulting from the displacement of the ions constituting the mobile sheet of the double layer and surrounding the colloidal particles, when two particles approach sufficiently near

each other, will increase with a diminution of the dielectric constant. This effect will decrease the rate of coalescence and tend to stabilise the sol.

(ii) From Mukherjee's theory of the electrical adsorption of the precipitating ions it follows that the adsorbability will increase in a medium of low dielectric constant. This effect will give sensitisation. The net effect will depend on the relative magnitudes of factors (i) and (ii).

In our case the effect of factor (i) has been either absent or less predominant than the effect of factor (ii) because stabilisation of the sol did not take place in any experiment. Factor (ii) can be utilised to explain both sensitisation and coagulation of the sol by non-electrolytes.

Mukherjee and co-workers (loc. cit.; also Choudhury, J. Phys. Chem., 32, 1481, 1928; Special Number of J. Indian Chem. Soc., 201, 1933) have also suggested that variation in the thickness of the double layer, changes in the interfacial tension of the medium etc., take place in the presence of non-electrolytes. It should however be stated that in the absence of any definite knowledge of variation. of the above properties of the double layer it is not quite correct to use these factors in explaining the results of sensitisation by non-electrolytes (cf. Weiser. J. Phys. Chem., 44, 101, 1930). It appears that the role of dielectric constant in the sense proposed by Wo. Ostwald and Freundlich may, to a very large extent, explain the results of sensitisation, although in some cases some other influences may have also to be taken into account.

34. In a recent paper Prasad and Nabar (J. Indian Chem. Soc., 10, 53, 1933) have studied the influence of non-electrolytes on the coagulation of colloidal ceric hydroxide by the thermopile method. They find that alcohols affect the stability with the progress of dialysis of the sol in the same manner as observed by Patel and Desai (loc. cit.) in the case of thorium hydroxide sol; sugars are however found to stabilise the ceric hydroxide sol and this effect increases with the progress of dialysis. The stabilising effect of sugars in this case may be due to the effect of factor (i) discussed in para. 33 as well as due to the cutting down of the preferential adsorption of the coagulating ion by the sugars. Regarding Prasad and Nabar's results it must be stated that in explaining their results they have assumed that the charge decreases regularly with the progress of dialysis. This is not justified in view of the fact that their sol contained initially appreciable amount of the peptising agent and therefore during dialysis the charge may first increase and then decrease.

CONCLUSION.

35. From the foregoing considerations it is apparent that changes which will be produced in the charge on colloidal particles during

dialysis are not so simple as many colloid chemists seem to imagine. It will also be clear that the results of viscosity and stability (towards electrolytes and non-electrolytes) cannot always be utilised for getting an idea about charge on colloidal particles. Under the circumstances it is difficult to understand how far one should consider as satisfactory the interpretations of the results of coagulation of colloids or of viscosity determinations whenever inferences have been drawn from them about changes in charge on the particles. There is thus a clear necessity of investigating simultaneously different properties of various colloidal solutions—cataphoretic speed, stability, viscosity etc.,—which have been dialysed to different extents in order to get a clear idea about relation between various properties.

Note—Paper by Desai and Borkar on Ferric Hydroxide referred to in para 6 has appeared in the December 1933 number of the *Transactions of the Faraday Society*, London,

SMOKE AND ITS PREVENTION

By

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Industrialism is rapidly spreading over our Indian cities which congested and crowded as they are, have already begun to feel the effects of mechanization and of comparatively large scale production.

Among the many problems which follow in the wake of industrial progress, is the abatement of smoke and dust and the taking of measures against atmospheric pollution.

In almost every city, where hydro-electric power is not available, coal is the chief source of generating electrical energy, supplying heat and producing steam and power. The boiler plant whether large or small is also invariably associated with factories, marine vessels, locomotives, trucks, cranes, shovels, steam rollers etc., and the general indication of such boiler plants in operation is the black smoke and dirt belching forth from their chimneys or stacks.

From the standpoint of hygiene, æsthetics and economics, it is highly desirable if not essential that the occurrence of smoke should be prevented and the air kept as free from dust as possible.

It is the primary concern of Municipalities to see to public health. Our markets are kept clean and we are supplied with pure, filtered, drinking water. The average individual is rather careful about clean food and water but how about the air that he or she inhales? The normal consumption of solids and liquids by the human system is about 5½ pounds in 24 hours but the air breathed, is over 35 pounds in the same period. One can imagine how harmful could the impurities in so much air be to the lungs and the chest. Is it not a logical step to legislate and make regulations in order also to prevent people from introducing obnoxious fumes, smoke and grit in the atmosphere which surrounds urban communities?

Of the industrial dusts, smoke and Municipal dust are no doubt harmful but far more serious problems are connected with industries such as granite quarrying in which the employees have to suffer from a dust concentration 40 times as much giving rise to such diseases as silicosis and consumption. However, as city atmosphere affects a large number of people, and as it actually pays not to have smoke, the subject should receive careful attention from the public at large.

Nuisance due to dust particles, spoiling of the æsthetic features of landscapes and residential quarters on account of unsightly streaks of smoke and the fouling of buildings, paintings, silverware, furniture etc., are sufficient reasons for passing legislation against smoke emission. It is estimated that in the city of New York, the damage caused by smoke amounts to the appalling figures of over Rs. 50 per annum per head. No wonder that of late there have been so many questions raised in the British Parliament to replace bituminous coal by some sort of smokeless fuel.

As far as the consumers of coal are concerned, they would have enough inducement to keep the smoke down if they only realize that smoke abatement also entails economy in fuel. It is only due to lack of knowledge and want of engineering skill that they unnecessarily lose money by continuing antiquated methods.

Smoke is the direct result of improper combustion or the burning of coal. To burn a shovelful of coal (say about 20 lbs. or 0·4 cu. ft.) it requires as much air as would be contained in a room 16′ x 16′ x 16′ (nearly 4,000 cu. ft.). From these proportions it may readily be observed that to thoroughly burn coal, enough air and proper contact are necessary. A little consideration will show that this is not so easy when coal is fired in a haphazard manner.

Visible smoke mainly consists of minute particles of carbon, tar and ash carried away by the products of combustion which are carbon-dioxide, water vapour and carbon monoxide with traces of hydrocarbons (due to incomplete combustion) together with the inert nitrogen of the air. Microscopic analysis shows that these particles are composed of groups of still smaller particles about two millionth part of an inch in diameter !

The actual loss of carbon in dense smoke amounts to about 1% of the carbon in the coal but in terms of heat units this loss itself is only about 3 to 4%. It is the loss of heat units in the accompanying carbon monoxide and hydrocarbons that is so serious and may amount to nearly 15% of the heating value of coal. It should be remembered, therefore, that when you see smoke, you actually visualize only a fraction of the total heat loss.

To make it more clear let us consider the combustion of a pound of carbon. If it is so burnt as to give only carbon monoxide instead of carbon dioxide, then we lose 10,600 B. Th. U.'s or a quantity of heat which could evaporate 3½ times as much water at 212°F. as is possible to generate from the heat of formation of carbon monoxide.

In the case of boiler practice, insufficient or sufficient (i. e. 40 to 50% excess) air might make a difference of as much as 10 to 15% in the cost of steam generation.

Now, coal is not a homogeneous substance. It is composed of hydro-carbons, carbon, ash and moisture, and when subjected to heat,

its volatile matter is first driven away leaving behind carbon mingled with ash which is called coke. Consequently, for combustion, air has to be so regulated as to first thoroughly burn the gaseous products which leave the coal as soon as it gets heated. When air is insufficient, the volatile matter instead of being thoroughly burnt, cracks up forming soot and other hydro-carbons of a more stable nature. Hence, lack of air is the primary cause of smoke.

The second cause may be put down as due to either too low or, too high a combustion chamber temperature. If the temperature is too low (as in the case of furnaces starting up) the fuel is not properly ignited and the gases leave the furnace decomposed and sooty. When the temperature is too high the heavy hydrocarbons and tar break up into soot in about a tenth of a second, *i. e.*, too quickly to enable air to react with them. Soot once formed is difficult to burn and flies up the chimney as smoke.

The third and general cause of smoky stacks is the improper design of furnaces. In most cases the combustion space is far too small to allow sufficient time for the gases and air to react. In others, the grate or burner construction is such that proper mixture and intimate contact of fuel and air are lacking.

The prevention of smoke, therefore, depends on the proper application of the general principles of combustion. It is worthwhile therefore to look into a few practical methods which are useful in ensuring thorough combustion.

When dealing with hand fired furnaces, only skilled firemen should be kept on the job. Small quantities of coal must be charged at a time as frequently as necessary and first allowed to coke on the plate in front of the grate. During the time that the gases distil off the charging door should be left ajar to let in plenty of secondary air. This is the first step taken in order that the hydrocarbons may be thoroughly burnt. The second step which consists of pushing the fuel on to the grate allows the coke to be uniformly fired with a set quantity of air.

In the case of larger units, the selection of a suitable stoker must not be overlooked.

There are many types of stokers and salesmen have a tendency to offer this important equipment without advising as to its suitability for a particular grade of coal. Stoker and furnace construction meant for a low volatile coal turns out to be inefficient when it is used for the firing of high volatile coal. Smokeless settings, well-designed arches and proper baffling to suit particular conditions, are highly important factors and money spent in rebuilding furnaces certainly is repaid.

Varying or excessive loads are often the cause of smoke from the stacks of even well-designed boiler furnaces and operation should be

more uniform. The forcing of boilers is a bad practice.

In the smaller units, lack of draft and turbulence are sometimes overcome by the use of steam jets by which means air can be injected into the furnace usually above the firing door. This practice may be resorted to only in cases where there is no other solution to the problem.

When the question of new installation arises, pulverised coal fired furnaces should be given serious consideration.

The more up-to-date plants have automatic combustion control devices, carbon-dioxide recorders, air preheaters and sometimes out of necessity they are equipped also with flue dust extraction devices.

The problem does not end with smoke abatement only. A lot of fly ash and dust escapes through the chimneys of large power stations (mostly those which operate on powdered coal) and settles down miles around in the surrounding district. When people not only demand relief from smoke but also agitate for freedom from dust and fumes it becomes a serious problem as considerable expense has to be incurred in providing dust extraction plant.

The types of dust extraction plants, commonly used in Europe, are (a) water film and spray (b) cyclone and (c) electrostatic. The capital costs of the water film and spray and multicyclone types are about the same and only about half the capital cost of the electrostatic plant. The total cost (including the fixed charges) of removing flue dust is very nearly the same for the three processes. The electrostatic precipitator though somewhat more expensive is said to have a high efficiency (90 to 95%) and has the advantage of separating out the dust in a dry form.

In cities where there are numerous factories located within limited areas, a drive should be made towards centralising the power plant. A large central power station would not only supply power cheaply but would also prevent smokiness by replacing a number of small inefficient units.

In England several attempts to prevent smoke have been made since the 14th century or still earlier. Numerous ordinances have been passed and committees appointed.

In recent years organised efforts have succeeded in greatly reducing smoke in some of the American cities. Smoke inspectors have been appointed and special regulations framed. If smoke of a certain density appears from a stack for a longer period than that specified, the ordinances are put into force. Qualitative smoke determinations are made ordinarily using the Ringelmann charts. These are large charts each cross ruled with lines of a certain thickness so that when placed at a certain distance from the observer, they appear of four shades intermediate between a white chart and a totally black one.

The colour density of smoke is then judged by comparing it with the charts.

In conclusion, it must be said that there is every justification to agitate for legislation for smoke and dust abatement in the interests of hygiene and economy. With our present knowledge of the scientific utilization of fuel, there should be little difficulty in ridding big cities like Bombay, Ahmedabad, Nagpur and Calcutta of the smoke nuisance.

RECENT WORK ON ANTIMALARIALS

By

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During the last fifteen years, a large amount of work has been carried out on the chemotherapy of malaria. Systematic investigations have been made on the relative values and limitations of the cinchona alkaloids, which still hold the field in the treatment of malaria, in spite of many attempts to replace them by the so called "modified alkaloids" or synthetic compounds. Attempts only in part successful, have also been made to correlate chemical constitution and antimalarial activity. The discovery in 1926, of "plasmoquin," a synthetic quinoline derivative which has been found to be of great value in treatment of human malaria, is an outstanding achievement of chemotherapeutic investigation, and has stimulated attempts to prepare synthetic antimalarials.

The first systematic use of cinchona bark as an antipyretic is due to Juan del Vego, physician attendant to the Countess Anna del Chinchon, wife of the Governor of Peru, who introduced the bark into Spain for treating ague on his mistress's estates, in or about 1639.

In 1820, Pelletier and Caventou in Paris isolated from the bark two alkaloids which they named quinine and cinchonine. Cinchonidine and quinidine were isolated thirtytwo years later.

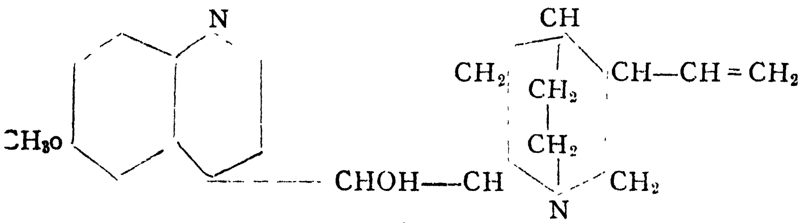
About 1860, attempts were made to introduce cinchona trees in India, Ceylon, Jamaica, Australia and Java, but success was attained only in India and Ceylon. Of late years, cinchona cultivation has declined in these countries, and has immensely increased in Java, which is now the most important cinchona district in the world. This is due to the extensive botanical and chemical investigations relating to the cinchona cultivation which have been carried out under the auspices of the Dutch East Indian Government.

The five chief crystallisable alkaloids present in cinchona bark are quinine, quinidine, cinchonine, cinchonidine, and hydroquinine; there are also present about twenty other alkaloids in smaller quantities which are non-crystallisable and amorphous.

While all these alkaloids have been known for long to possess antimalarial properties, there was no general agreement regarding their relative efficacies. Goodson, Henry and Macfie[1] who have recently reinvestigated this problem, using alkaloids of undoubted purity and

more refined technique for biological tests, conclude that hydroquinine is the most effective, the remaining four being approximately of equal value.

The chemical constitution of quinine is represented by (I). It is thus p-methoxy-y-quinoyl-β-vinyl-2-quinuclidyl-carbinol, the two component rings being called the quinoline and the quinuclidine residues. Quinidine is a stereoisomeride of quinine, and hydro-quinine contains the saturated ethyl ($-CH_3-CH_2$) group in place of the vinyl ($-CH=CH_2$) group of quinine. Cinchonine and cinchonidine which are stereoisomerides only differ from quinine in the absence of the methoxyl group.



(I)

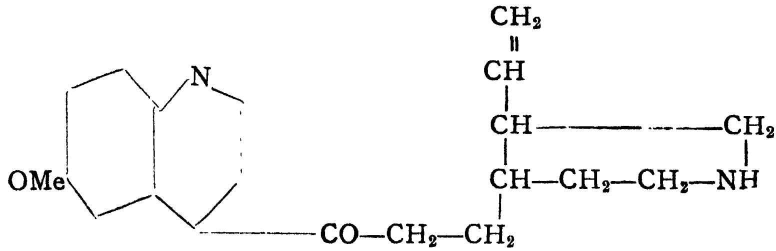
Detailed study has been made of the physiological action of quinine, which is found to have a strongly antipyretic action, and bactericidal, narcotic and local anæsthetic action, in varying degrees.

Attempts which have been made to ascertain the particular molecular arrangement present in these alkaloids which is responsible for their biological activity, have given results which are rather vague and indefinite. It appears that the quinoline methoxyl contributes to a small extent to the antimalarial activity. Hydrogenation of the vinyl group of the quinuclidine ring gives methyl hydrocupreine which is as active as quinine, but more toxic. The dehydrocompound from quinine containing the group $-C{\equiv}CH$ in place of $-CH=CH_2$ is only half as active. The conversion of the $-CH=CH_2$ group to $-CHOH-CH_3$ by the addition of water across the double bond leaves the activity unchanged. The rearrangement of the vinyl group to the $=CH-CH_3$ group gives the interesting compound isoquinine which is as active as quinine, although a little more toxic.

Other points of the variation of the quinine molecule have also been investigated. The oxidation of the secondary alcoholic group gives ketoquinine, while reduction to CH_2 gives the methylene compound, cinchene, which is extremely toxic producing tetanus and death. Fracture of the quinuclidine ring yields quinicine (II) which is highly toxic, being a strong convulsant, and fatal in larger doses.

Little information has been made available regarding the simple quinoline derivatives, whereas simple quinuclidine compounds do not

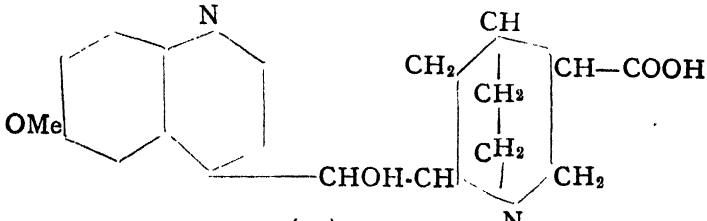
seem to have been investigated. Strangely enough, the antipyretic action of p-methoxy quinoline is less than that of quinoline itself, whereas p-methoxy quinoline-y-carboxylic acid is almost completely inactive, as might be anticipated from the presence of the deactivating carboxyl group.



(II)

Earlier attempts at preparation of anti-malarials were made by modifying the structures of cinchona alkaloids. The so-called "modified alkaloids" which were investigated were the carboxylic acids produced by the oxidation of the $-CH{=}CH_2$ (vinyl) group of the cinchona alkaloids to the $-COOH$ group and their esters.

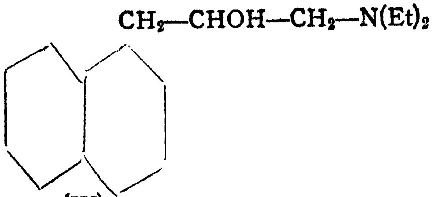
Thus quinine, quinidine, cinchonine, cinchonidine gave quintanine, quitenidine, cinchotenine, and cinchotenidine. Quitenine (III) is found to be inactive but according to Geisma, Weise, and Tropp,[2] the activity is regained in the ethyl ester called ethyl-quitenine on esterification of the carboxyl group with ethyl alcohol. The methyl, propyl and other alkyl quitenines have also been examined, and the interesting generalisation has been drawn that antimalarial activity increases as the homologous series is ascended, reaching a maximum at bytyl or amyl. Similar relationships appear to hold good in the cases of the esters of cinchotenidine, quitenidine, and cinchotenine. However none of the compounds approaches quinine in efficiency against bird malaria.



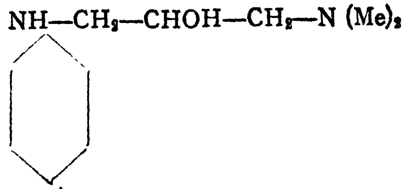
(III)

Proceeding on the assumption that the secondary alcoholic hydroxyl group of quinine is essential for antimalarial activity Forneau and collaborators[3] have prepared a number of relatively simpler aminoalcohols of the naphthalene series like (IV), (V) and (VI) of which some

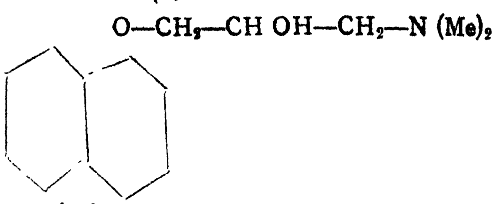
like (V), and (VI) were active against bird malaria but inactive against human malaria.



(IV)

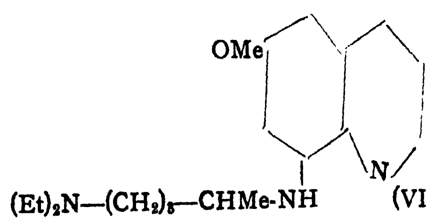


(V)



(VI)

A new and most promising clue in the search for synthetical anti-malarials has been provided by the discovery in 1926 of plasmoquin, a synthetic quinoline derivative. The structure of the drug is not known with certainty, but according to Hörlein, the director of the pharmaceutical department of the I. G. Farbenindustrie, the compound is N-diethylamino-isopentyl-8-amino-6-methoxy quinoline (VII), thus differing from quinine chiefly in the absence of the quinuclidine nucleus with the two intermediate methylene groups.



(VII)

First biological experiments were carried out with the new compound on the parasites of bird malaria, in the case of canaries which were found to be most suitable for the purpose by Roehl. The experiments were then extended to human malaria, in which some success was achieved. Although the high hopes entertained for

plasmoquin in the beginning have not been fully realised, it is a compound of great value in the treatment of malaria in human beings.

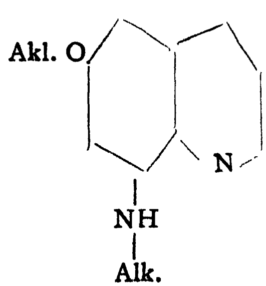
The antimalarial effects of plasmoquin were first demonstrated by the use of Roehl's technique, which depends on the fact that it is possible to infect birds with plasmoquin relictum, thus communicating to them a malady, the evolution of which resembles that of human malaria.

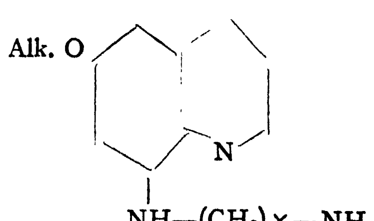
By means of this new procedure, the activity of a synthetic compound can be so easily tested that it may be hoped that plasmoquin is but the first of a series of still more efficient antimarials to be discovered in future.

Since the discovery of plasmoquin, which apart from the cinchona alkaloids is the only known compound which has shown promise in the treatment of human malaria, it has been largely adopted by subsequent workers as model upon which to base the synthesis of new compounds.

In England, systematic research on synthesis of new antimalarials, planned as a campaign against malaria, has been initiated by Barger and Robinson,[4] with the co-operation of the joint Committee on Chemotherapy formed by the Medical Research Council and the Department of Scientific and Industrial Research, and a number of new compounds of possible antimalarial activity have been made to which a brief reference may be made.

Aminoalkyl quinolines of the types (VIII) and (IX) bearing structural resemblance to plasmoquin, have been synthesised by Baldwin,[5] and aminoalkylquinolinium salts by Sheshadri.[6] Kermack and Smith[7] prepared 4-piperidino-and 4-piperazino-2-methyl quinolines; while Kermack and Muir [8] have extended the work by substitution of a more complex sidechain containing two nitrogen atoms in place of the simple piperidine or piperazine ring. Of a different type are the pyrrole-quinolines obtained by Mrs. Robinson,[9] showing similarity to the alkaloids harmine and harmaline, which are known to possess antimalarial action.





IX.

(VIII)

It is gratifying to note that some work in this direction has also been done in India.

J. N. Ray and collaborators[10] have synthesised several compounds amongst which are a glyoxalino-quinoline, pyrryl-indoles, and condensation products of cotarnine and phenols.

Brahmachari and coworkers[11] have prepared a number of quinoline derivatives including dimethyl-amino-styrryl-quinolines, quinoline-amido-acetamides, carbamido-quinolines, quinoline-amino-acetyl-p-arsenillic acids and 8-β-aminoalkyl-amido-quinolines.

As the results of the biological tests on the therapeutic activities of many of the synthetic compounds referred to in the article, are not yet published, it is not possible at this stage to make any generalisations.

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ABSORPTION OF LIGHT IN POLYATOMIC MOLECULES

By

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Studies in the absorption spectra of solutions in the ultra violet and the visible region of the spectrum have yielded results which are of great importance to the chemist, inasmuch as they have given sufficient clues to decide between possible alternatives in the structure of complex organic molecules. Such studies have often been employed in the identification and purification of certain organic compounds. A detailed knowledge of the light absorption in various substances has also proved useful in devising light filters for the isolation of various radiations in the different parts of the spectrum. Besides these practical applications, on the theoretical side observations on the absorption spectra of a large number of coloured and colourless compounds have enabled many workers to propose theories regarding the relations between the colour and the constitution of organic compounds. In this way certain groups of atoms in the complex molecule are recognised as the seat of colour, while the others are supposed to help the formation of colour. These theories interesting and instructive as they are, have met with little success, as they give no quantitative information as to the position and intensity of an absorption band in a given compound, nor any insight into the mechanism by which the light energy is absorbed in a molecule.

Baly[1] and later Henri[2] and others proposed a theory of a semi-quantitative nature regarding the position of the absorption bands in the ultra violet region. According to these authors the position of an ultra violet absorption band is mainly governed by one of the fundamental vibration frequencies of the molecule in the infra-red region of the spectrum. The infra-red frequency when multiplied by a suitable whole number gives the exact position of the absorbed ultra violet frequency. The idea underlying this relation is that the molecule absorbs a definite number of quanta of lower energy which appears later on in the ultra violet as one whole larger quantum. No fixed rule is given regarding the selection of the particular infra-red frequency and obviously, the one suited for the purpose is chosen. Moreover, it is now well recognised, that the ultra violet or the visible, absorption is

influenced by the energy of the outer electrons in a molecular system, while the inner vibrations of the kernels or the nuclei which have considerably lower energy, are mainly responsible for the absorption in the near infra-red. No definite relation between these two energies, electronic and vibrational in a given molecular state, is yet known. However, it may be noted, that some diatomic molecules of which the electronic and vibrational frequencies in a given state are definitely known from the recent data on the band spectra, do show simple relations which may not be merely a matter of coincidence. In Table 1, the electronic (ν) and the vibrational (ν_v) ground frequencies for some of the excited states of the CO molecule are given. It will be seen that the former is a whole multiple (n) of the latter, and the deviation from the observed value of ν_c is only about 0·5 per cent. Other instances of a similar type can be quoted.

TABLE 1.

$\nu_v{}^3$.	n	n × ν calc.	$\nu_c{}^3$ obs.
1914	52	99528	99730
2081·5	42	87423	86892
1497·63	43	64398	64729
1105	58	64090	64060
1173	49	57477	57763
1726·5	28	48342	48530

Any approach to the subject of the light absorption in polyatomic molecules must be made with caution. Before we can give a complete explanation of the absorption by a molecule in the free gaseous state, ideas regarding the absorption by solutions or even by liquid substances are likely to be in error. As yet the mechanism of light absorption, in the infra red and the visible or the ultra violet, is understood to a fair degree of accuracy, only in the case of simple diatomic molecules in their stable or metastable forms. The best we can do therefore, for the polyatomic molecules, is to proceed from the analogies offered by the diatomic molecules, and utilise such of the data as are available from the band absorption of such molecules.

The analysis of the absorption band spectrum of a diatomic molecule gives the energy value of the outer electrons, as also the values of the nuclear energy of vibration in the ground and the various excited states. The ground vibrational frequency thus obtained in the lowest energy state of the molecule should then be comparable with its fundamental frequency in the infra-red. In Table II, the third column shows the value of the absorbed infra-red frequency, as measured directly or

as obtained from the data on the Raman effect. The fourth column shows the same value as found from the band spectra.

TABLE II.

Vibration frequency in diatomic molecules.

Molecule	Bond	ν^4_v (i. r.)	ν^3_v (band sp.)	Molecule	Bond	ν^4_v (i. r.)	ν^3_v (band sp.)
H_2	H-H	4155	4264	HCl	H–Cl	2780	2840
N_2	N=N	2329	2345	HBr	H–Br	2479	2603
O_2	O=O	1552	1565	HI	H–I	2233	——
P_2	P=P	468	450	CO	C–O	2155	2149
S_2	S=S	470	426	NO	N–O	1877	1892
Cl_2	Cl-Cl	556	561				

The fair amount of agreement observed in Table II, between the values of vibration frequencies as obtained by the two independent methods, leads us further to examine the question of polyatomic molecules.

A characteristic feature of the polyatomic molecules as revealed by the Raman effect, is that the vibration frequency of any of the individual atomic linkages in them remains constant within narrow limits, whatever the general structure of the molecule. Thus such groups as C–H, C=O, C=C, C=N etc. have definite frequencies which are always found in the molecules containing them. Furthermore, it is interesting to note that these atomic linkages when present in the free diatomic states again exhibit the very same frequencies in their ground vibrational states. Table III shows a comparison of the vibration frequencies of some of the diatomic groups, in the combined and in the free state.

TABLE III.

Vibration frequencies in diatomic groups.

Molecule	Bond	ν^4_v Raman	ν^3_v band sp.	Molecule	Bond	ν^4_v Raman	ν^3_v band sp
CH_4	C–H	2910	2815	$BiCl_3$	Bi–Cl	240,288	218*307
C_2H_4	C=C	1630	1630	$SnCl_4$	Sn–Cl	367,401	350,431*
Carbonyl	C=O	1722	1724*	O_2	Si-O	802,1227	844*1236
Nitrile	C=N	2172	2144*	Sulphate	S=O	617,1107	609*1124
N_2O	N=O	2223	2345*	Chromate	Cr=O	787,870	746*897
NO	N=O	1877	1892	Vanadate	V=O	870	865*1092
Nitrate	N=O	1047	1030*	Manganate	Mn=0	788,833	759*836

According to this table we recognise for the first time that the individuality of a diatomic group, as regards its characteristic vibration frequency is always preserved, either in the free state or while forming the part of a molecule. This is, however, not the case with the electronic frequency, for the electronic energy of a diatomic molecule would suffer much change while forming the part of a polyatomic molecule. Here, on account of the neighbouring linkages and the heavier mass of the system as a whole, the electronic energy would be considerably damped, with the result that the absorption wave lengths in the visible or the ultraviolet are shifted towards the red side of the spectrum, the amount of shift varying with the degree of damping. The decrease in the electronic energy of the diatomic system would also lower the number of possible vibrational transitions between the two electronic states, and, therefore, the region of absorption now covered by the polyatomic molecule is shorter than before.

In order to test the correctness of the views given above, we have to look for the actual band spectra of a large number of molecules in absorption. It is found, however, that only a few of these have been investigated so far, mainly because their analysis is rendered difficult on account of their complexity. The main vibration frequency in each of them however is easily found from the separation of the principal band heads. This would give us the frequency of that part of the molecule which causes in general the absorption of light, and thus we should identify the absorbing group by comparing the principal vibration frequency of the molecule with that of the absorbing group in the diatomic state. In the following table, the principal vibration frequencies, together with the frequencies of the active group in the free state, for some of the molecules are given : (Table IV.)

The results shown in the above table confirm the views outlined before. It is also found that in the instances cited above, the original band system of the active group is displaced towards the red end, and the region covered in absorption is also much smaller. Further it will be seen that the active group is more unsaturated in character, relative to the rest of the molecule. It may be concluded therefore, that in organic molecules such groups as $C = O$, $C = C$, $C = N$, $N = N$ and others form the main seat of absorption.

Some of the vibration frequencies as observed in the band spectra are marked with an asterisk in table III and IV. These represent the vibration frequency of the diatomic molecule in one of the observed excited molecular state. When this same frequency occurs in absorption in a polyatomic molecule, it probably means that the diatomic group in question is in an excited state, and imparts to the molecule its observed chemical activities. It would be possible to clarify this point, if we could observe any change in the vibration frequency

TABLE IV.
Principal vibration frequencies in polyatomic molecules.

Molecule	Active group	Polyatomic Frequency	Frequency in Diatomic State.	
Formaldehyde[5]	C=0	1120	1182*	Hopfield Birge upper level.
	C=0[6]	1723	1724*	Cameron upper level.
Phosgene[7]	C=0	422	2149∿1724*	Cameron system.
Benzoquinone[8]	C=0	1110	1105*	Merton-Johnson upper level.
			1182*	Hopfield Birge upper level.
	C=0	422	2149∿1724*	Cameron system.
Diacetyl[8] ...	C=0	1411	1497*	4th. positive upper level.
Glyoxal[8] ...	C=0	1418	1497*	4th. positive upper level.
Hydrazine[9] ...	N=N	470	...	...
Azobenzene[10] ...	N=N	652	2345∿1679*	Birge Hopfield abs-system.

of the molecule by suitable electronic excitation. This excitation could be brought about by the absorption of light in the visible or the ultra violet. If then, for such a molecule, Raman photographs are secured, while the same is exposed to the ultra violet light, the scattered radiations on the spectrograms would be different from those observed ordinarily *i. e.* when the exciting ultra violet light is absent. Such experiments would be possible only where the absorbed radiations do not bring about any immediate chemical change in the system, or cause fluorescence in the molecule. Some of the results of Ghosh [11] may be cited to support this argument. These are shown in table V. The frequency shifts which are common to the ordinary visible excitation, as well as to the ultra violet excitation, are omitted from the table. Those of the frequencies which are present exclusively under the ultra violet excitation are shown in the second column, while the third column shows the frequencies which are observed ordinarily in glass apparatus which cuts off most of the ultra violet light, and which are totally absent when quartz apparatus transmitting all the radiations is used. This difference in the two cases is not due to any failure to observe some of the faint lines in the spectrograms. For example, if this were so there is no reason why such a strong line due to the frequency shift 426 in the case of ethyl alcohol should be totally absent when the same substance is under the influence of the ultra violet radiations. There is no doubt that in the latter case we are

dealing with a molecule which has changed its vibration frequency due to a change in the molecular energy level, under the influence of absorbed radiations. However, in order to draw any conclusion as to the energy level reached by a molecule as a result of light absorption we need much more data, obtained from an examination under strictly controlled conditions, of a large number of substances.

TABLE V.

Raman frequencies in excited molecules.

Molecule	Ultraviolet excitation	Visible excitation.
Methyl alcohol		no difference
Ethyl alcohol	506,2741	426, 1094, 1273
Acetic acid	288, 376, 1002, 1276	440
Ethyl formate	609, 1013	2878
Ethyl acetate	...	938, 1005, 1044
Sodium acetate	...	647, 1649
Ethyl malonate	...	2875.

From what has been said above, it would be sufficiently clear that the whole question of the absorption of light in polyatomic molecules needs a re-examination in the light of the new knowledge gained from the band spectra and the Raman effect. While the existing data on the solutions are useful for their practical applications, in order to understand anything regarding the mechanism of light absorption, we need more quantitative experiments, probably along the lines suggested in this paper.

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THE BLEACHING OF SHELLAC

By

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Shellac is not a single chemical compound but consists of a mixture of several resin acids, wax and a colouring matter called erythrolaccin. The bleaching of such a complex material is a delicate operation especially as shellac is prone to become insoluble on continued heating or in contact with hydrochloric acid, or become hydrolysed to a sticky resinous mass on contact with caustic alkali. A physical method of obtaining a pale resin would be to extract the colouring matter, erythrolaccin with ether leaving behind about 70% of the original shellac which from alcohol solutions gives a colourless film. But such a film is brittle and lacks adhesion as the ether extracts, besides the colouring matter, the resin acids which impart to shellac its unique property of good adhesion and toughness combined with hardness.

The colouring matter could be removed as described by Wolff (1) by filtering the alcoholic solution of shellac through animal charcoal. But the bleaching is incomplete and uneconomical.

According to a method by Dutt (2) the ethyl alcohol solution of shellac is neutralized by ammonia, ethyl amine, or calcium oxide and agitated with Indian bauxite, and filtered.

According to Daum (3) the colouring matter is first taken up by fat (*e. g.* by treating shellac with a hot aqueous solution of cocoanut oil) and the fat with the colouring matter is then extracted with petroleum ether.

Among the chemical methods of bleaching may be mentioned several processes which involve the oxidation of the colouring matter. By leaving shellac in contact with hydrogen peroxide for several days a light coloured resin can be obtained. The bleaching is, however, incomplete and costly. Hydrogen peroxide does not bleach alkaline solutions of shellac. According to Venugopalan (4) reducing agents like sulphurous acid give a green coloured product, the decolorization being incomplete. Treatment of shellac with drastic oxidizing agents like nitric acid leaves behind a yellow sticky mass, the rupture of the heavy molecules of resin acids taking place at the double bond and hydroxyl groups.

The most common bleaching agent is chlorine. On account of its great activity and the possibility of rendering shellac insoluble

direct chlorination of shellac is not feasible. But this can be accomplished according to the method of Gratzel (5) by leading into the alkaline solution of shellac chlorine which has been diluted with a large quantity of air or other inactive gases. It is more convenient, however, to add chlorine in the form of sodium hypochlorite. According to the method of Rosenhagen (6) the production of sodium hypochlorite from sodium chloride and bleaching of shellac is carried out electrolytically in one operation.

Sodium hypochlorite should be prepared fresh every time before bleaching, the method described by Zoller (7) being most convenient. Bleaching is best carried out between 30° to 34°C.

The chief factor that enters into the economy of bleaching shellac on a commercial scale, especially in India, is the cost of sodium hypochlorite. Hence professional bleachers should select low hypochlorite consuming shellacs consistant with price. Shellac in general consumes less hypochlorite than seed lac, being comparatively free from the dye laccaic acid and nitrogenous matter. But there is a tendency among bleachers now-a-days to use more and more seed lac for bleaching, partly on account of its cheaper price and partly because the wax can be easily filtered out of the hot alkaline solution, whereas, with shellac, the wax is in a more stable suspension owing to the previous heat treatment it has undergone, and filtration is difficult. Addition of a small quantity of kieselguhr to the solution and stirring makes the removal of wax easier.

Seed lac contains in varying amounts lac dye, insect scarf, and woody material as impurities, and these are chiefly responsible for the increased consumption of the bleaching agent. One gramme of water extractable material consisting of laccaic acid, sugars, and proteins is present on an average in every 20 gm. of stick lac, and one gramme of this extracted material requires for bleaching its alkaline solution to a yellow colour 42 c.c. of a solution of hypochlorite (containing 3% available chlorine), whereas 20 gm. of a well washed Khair seed lac takes only 30 c.c. of the same hypochlorite solution for bleaching its alkaline solution to a light wine colour.

More than the dye the albuminous matter and the ammonia salts present in seed lac are responsible for the excess of sodium hypochlorite consumed. This is evident from the following experiment: 15 gm. of a sample of shellac required 28 c.c. of sodium hypochlorite (having 3% available chlorine) for bleaching its alkaline solution to a light wine colour. But when its nitrogen content was raised by half per cent. by addition of ammonium sulphate to the alkaline solution it required 62 c.c. of the same bleaching solution. When its nitrogen content was raised by one per cent. it required 91 c.c. of the hypochlorite; the

bleaching was still unsatisfactory and the colour tended to return on keeping the solution.

The dye and the albuminous matter can, however, be easily washed out if the freshly cut lac is immediately washed, as then the dye and the albuminous matter will be in a soft condition. But with stick lacs stored for a long time the dye and the albuminous matter will have hardened and it will be difficult to wash away these from the interstices of the lac grains. The water used in washing must not be hard, otherwise, the removal of the dye from the seed lac will be incomplete due to the precipitation of calcium salt of laccaic acid in the interstices of the lac grain.

Washing with Fuller's earth, or with weak alkalies such as sodium carbonate or borax will be useful. The greater the concentration of sodium carbonate the easier it is to remove the dye; but, at the same time, loss is encountered on account of a portion of the lac also getting into solution and being washed away. Hence a compromise has to be effected. The advantage of washing with sodium carbonate will be clear from the following experiment. A sample of 'punki' stick lac gave on machine washing with tap water a 68% yield of seed lac. 20 gm. of this seed lac required 82 c.c. of sodium hypochlorite solution (containing 3% available chlorine) for bleaching its alkaline solution. Further mechanical washing of this seed lac with 0·025% sodium carbonate solution resulted in a loss of 2% of seed lac. But 20 gm. of this seed lac now required only 70 c.c. of the hypochlorite solution. The concentration of the sodium carbonate solution could be increased up to 0·1% with beneficial results.

In dealing with shellac we have to deal with different impurities, namely resin and orpiment. Resin is present in most TN samples being added during its manufacture in order to help the melting of difficultly fusible lacs. It has no adverse effect on bleaching. Orpiment on the other hand which is added to lighten the colour of TN shellacs has a marked effect in increasing the quantity of bleach required. So long as appearance remains one of the chief criterions in the purchase of shellac orpiment will continue to be an ingredient of TN grades. It is desirable to know, however, to what extent its presence can be tolerated in bleaching.

To obtain definite information on this subject it is necessary to compare samples made from the same seed lac with and without orpiment. This is of extreme importance as some dark coloured samples require more than twice the quantity of bleach that is required for light coloured ones. Seed lacs ranging from fairly light colour to dark colour were taken and various amounts of orpiment incorporated. 10 gm. of the above powdered samples were dissolved in 100 c.c. of sodium carbonate solutions of various strengths at 60^{o}–65^{o}C on a

water bath for 2 to 3 hours and the solution then decanted. Sodium hypochlorite solution whose available chlorine had been previously determined and adjusted to contain 4·7% available chlorine was added in lots of 3 c.c. in the beginning and in fractions of one c.c. towards the end of bleaching, (the next lot being always added after ensuring the absence of free chlorine with the help of starch-iodide paper). The results are incorporated in Table 1.

TABLE I.

Sample No.	Orpiment content % 1	c.c. of bleach required in solution of		
		1% Na_2CO_3 2	2% Na_2CO_3 3	5% Na_2CO_3 4
1 (control)	nil	11·8	14·0	14·5
2	1·2	12·1	17·0	18·5
3	2·3	12·6	21·5	...
4 (control)	nil	10·0	...	...
5	0·13	10·5	...	...
6	0·25	10·5	...	...
7 (control)	nil	...	12·0	...
8	0·08	...	12·2	...
9	0·15	...	12·3	...
10	0·30	...	13·4	...

It will be evident from the table that with increasing quantity of orpiment the amount of bleach required increases. With small quantities of orpiment, *i. e.* below 0·3%, the difference is small. When the concentration of alkali is increased, however, the difference becomes marked (vertical columns 3 and 4 in Table I). This is to be expected as with increasing concentration of alkali more orpiment goes into solution. It was also noticed that when the alkaline solutions were treated with excess of hypochlorite the controls took the least time to attain the light colour while the others took longer periods in order of their orpiment content.

The fact that orpiment uses up a portion of the hypochlorite is established thus. A sodium carbonate solution of 0·1 gm. of precipitated orpiment (As_2S_3) is left in contact with a known excess of standard sodium hypochlorite solution for 72 hours, the unused available chlorine being determined at the end of that period. It is found

by this method that 5·3 c.c. of sodium hypochlorite solution (having 4·76% available chlorine) is taken up by by 0·1 gm. of orpiment.

The concentration of sodium carbonate solution itself influences the amount of sodium hypochlorite consumed even when orpiment is absent. This is clear from Table II. Vertical columns 2 and 3 represent in c.c. the amount of bleach (having 5% available chlorine) required for 10 gm. of shellac.

TABLE II.

1 Concentration of Na_2CO_3	2 Shellac (light coloured)	3 Shellac (dark coloured)
1%	11·0	5·5
2%	11·5	5·9
5%	13·5	6·5

Increase of alkalinity often results in the precipitation of a gelatinous mass of shellac. Another danger of higher concentration of alkali is the hydrolysis that will be brought about while dissolving. It is therefore preferable to dissolve shellac in a carbonate solution less than 2% strong. Some old lacs take longer time to dissolve in this concentration, preliminary swelling taking place before dissolving.

When the bleaching operation involves the use of large quantities of hypochlorite the quality of the resulting bleached lac is generally poor. The colour is dull and the bleached lac soon becomes insoluble.

Apart from the oxidation of the colouring matter during bleaching, chlorine adds itself at the double bond of the resinous constituents of shellac. Hence the iodine value decreases from about 18 in ordinary shellac to about 9 in bleached lac. Addition of a trace of cobalt hydrate is helpful during bleaching, the action of cobalt hydrate on sodium hypochlorite being the liberation of oxygen, which is supposed to direct the process of bleaching chiefly towards one of oxidation. The presence of sodium silicate is also supposed to increase the efficiency of sodium hypochlorite.

After completion of bleaching, the alkaline solution may be partially neutralized and concentrated, and this solution can be used as such for playing cards, for stiffening felt hats, and as gloy substitute. For obtaining the solid resin the alkali is neutralized with hydrochloric acid (dilute), dilute sulphuric acid, or acetic acid. The first one gives a more granular precipitate of bleached lac, while acetic acid gives a product which has less tendency to become infusible. In order to mitigate the harmful effect of any free chlorine present the alkaline

solution is treated with sodium sulphite before the precipitation, or, as recommended by Watson and Mulany (8), the granular precipitate of bleached lac is treated with sodium thiosulphate solution before washing. The last traces of electrolyte which are ordinarily difficult to remove by washing can be removed from bleached lac by electro-dialysis. The resulting bleached lac can be stored in the form of dry powder (vacuum dried containing about 6% moisture), or under water, or in the form of spirit varnish. When stored under water bleached lac retains its solubility for a longer time because the hydrochloric acid formed from the chlorine present in bleached lac gets diluted by the water. Spirit solutions of bleached lac become nondrying when preserved for a long time. The chlorine present in bleached lac forms hydrochloric acid in presence of moisture which acts as a catalyst bringing about the esterification of bleached lac with alcohol. The ester being like molasses in consistancy renders the film tacky. Owing to these defects too much time should not be allowed to lapse between production and consumption of bleached lac.

ACKNOWLEDGMENT.

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LIFE AND WORK OF SIR P. C. RAY, KT., C.I.E., PH. D., D. SC.

By

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A brilliant chemist, Professor Sir P. C. Ray, is aptly known as the Father of Chemical Research in India. Not only he has been himself enthusiastically engaging his attention in the pursuit of Chemistry but he has always been ready to sacrifice his all for inspiring the love for research among students who were fortunate to sit at his feet.

The Indian Chemical Society has recently published a Jubilee Volume to commemorate the valuable services rendered by Sir P. C. Ray to the cause of science. The publication, in this volume of the Bombay University Journal, of the following short account of Prof. Ray's life and the scientific work done by him will be a fitting appreciation of his achievements.

Prafulla Chandra was born on 2nd August, 1861 in a small village in Khulna District in Bengal. His father was a very enlightened person and took keen interest in education. He himself was a good scholar of Persian and also knew a little bit of Arabic and Sanskrit. Being a person of advanced views he felt the need of educating the boys and girls of his village and to that end he started the first Girl's School and a Middle English School, mostly at his own expense.

Prafulla Chandra and his two elder brothers were given their early education at their father's school which is still in existence. To enable his elder brother who had passed the minor scholarship examination, to prosecute his studies further the family moved to Calcutta in August, 1870. Prafulla Chandra was admitted into the Hare School where he had a very distinguished career. But in August, 1874 he got a severe attack of dysentry and had to give up his studies for two years. While a student of the Hare School and during his illness Prafulla Chandra read the works of several English writers and contracted a liking for English literature. At about the same time he was struck with the close similarity of Latin to Sanskrit and lost no time in learning up the new language.

After his recovery—the attack of dysentry having left him a permanent valetudinarian—he took admission into the Albert School where he was much liked by his class teachers and his liking for the English

literature grew into love because of the excellent method of teaching of Krishna Behary Sen, the rector of the school.

After passing the Entrance Examination Prafulla Chandra joined the Metropolitan Institution particularly with a view to receive instructions in English literature, prose and poetry, from Sir Surendranath Banerjee and Prasanna Kumar Lahiri who were distinguished teachers of the subject. While a student of the Institution he was also attending the lectures in Physics and Chemistry at the Presidency College, Calcutta, as an external student. It was at this time that the seeds for a rich harvest were sown. Prafulla Chandra was very much influenced by the lectures and the experimental skill of Prof. Sir Alexander Pedler and began to acquire a taste for chemistry. He soon saw that the future progress of India depended upon the advancement of scientific education.

At about the same time Prafulla Chandra appeared privately for the Gilchrist Scholarship examination and was one of the two Indian winners. This gave him an opportunity to go to Europe to prosecute his further studies in chemistry. His parents did not object to his going out of India and he proceeded to England with the idea of joining the University of Edinburgh which was in those days considered to be a seat of learning. He received his lessons in chemistry from Professor Alexander Crum Brown under whom he afterwards worked for the degree of Doctorate of Science. He took the B.Sc. degree in 1885 and D.Sc. in 1887 on the submission of a thesis. Some of this work has been published in Dr. Ray's first paper on 'Mixed double sulphates of copper and magnesium group' in the proceedings of the Royal Society of Edinburgh.

Dr. Ray was the recepient of the Hope Prize Scholarship in chemistry during 1887-88 and this gave him an opportunity of assisting Professor Brown and Dr. Gibson in the laboratory teaching. The same year he was elected as the Vice-President of the Edinburgh Chemical Society. Professor Sir James Walker who has lately retired from the chair of Physical Chemistry at the Edinburgh University and Professor Hugh Marshall, the discoverer of persulphuric acid, were his colleagues at the chemical laboratory.

In 1888, Dr. Ray returned to India. A year after, he was appointed as an assistant professor of chemistry at the Presidency College, Calcutta, where he ultimately succeeded Professor Pedler. Soon after his appointment he started research work on various problems but it was in 1896 that Dr. Ray made his celebrated discovery of mercurous nitrite. He found that when dilute nitric acid is placed in contact with mercury at about 30^{o}, fine yellow needles of mercurous nitrite are deposited on the surface of mercury. Thus he was the first not only to indicate the mode of formation but also to isolate the mercurous

salt which was then unknown to the chemical world. The results of this remarkable discovery were published the same year in the Journal of the Asiatic Society, Bengal, Zeitschrift für Anorganischen Chemie and in the Proceedings of the Chemical Society, London, and Dr. Ray entered upon a new era of his scientific career. He then proceeded to study the chemical behaviour of mercurous nitrite and found that it slowly dissolves in the mother liqour forming (i) $Hg_2(NO_3)_2$ and (ii) a basic nitrate. When a solution of mercurous nitrite is spontaneously evaporated (i) $Hg_2(NO_2)_2$, 2 H_2O, (ii) two basic mercuroso-mercuric nitrites and (iii) a basic mercuric-nitrite are formed. When mercurous nitrite is dissolved in water 78% of it gets dissociated into mercurous mercury and mercuric nitrate, the limit to dissociation being caused by the formation of a stable compound mercuroso-mercuric nitrite.

While attempting to elucidate the mechanism of the formation of mercurous nitrite Dr. Ray took no time in finding that the presence of nitrous acid is essential for the dissolution of mercury into nitric acid. In the early stages of the reaction nitric acid and nitrous acid, which is always present in nitric acid in small amounts, both react with mercury as

$$2\ Hg + NO_2\ \boxed{H+HO}.\ NO_2 = Hg_2(NO_2)_2 + H_2O$$

Later on the nitric acid reacts with mercuric nitrite yielding mercurous nitrate and nitrous acid. After some time the quantity of nitrous acid reaches a constant value and it then begins to act as a catalytic agent between nitric acid and mercury. The third stage of the reaction is then represented by

$$4\ Hg + 4\ HNO_3 = Hg_2(NO_2)_2 + Hg_2(NO_3)_2 + 2H_2O$$

The rate of this reaction of mercury with nitric acid was found by him to be influenced appreciably by the presence of other substances: it was retarded by ferrous and ferric salts and accelerated by the salts of sodium and manganese.

When mercurous nitrite is heated it decomposes into mercurous nitrate and nitric oxide mixed with very little nitrogen peroxide and there also appear small quantities of metallic mercury, orange coloured mercury oxide and a basic nitrate. In order to explain the formation of the products of decomposition Dr. Ray assigned the oxylic, $HgO.\ NO$, and the non-oxylic, $Hg.\ NO_2$, formulae to mercurous nitrite and substantiated them by the reaction of ethyl iodide with mercurous nitrite in which both ethyl nitrite and nitro-ethane are obtained.

Encouraged by these successes Dr. Ray opened up new avenues of research. From mercurous nitrite to mercuric and mercurous hyponitrites was the next step. With this end in view he treated a solution of mercurous nitrite with the sodium hyponitrite but found that a mixture of mercuric and mercurous hyponitrites is formed. The

separation of the two hyponitrites was not difficult for him. He soon found that if the solution of mercurous nitrite is first treated with sodium chloride and filtered and sodium hyponitrite is then added to the filtrate a fairly pure sample of mercuric hyponitrite is obtained. However, Dr. Ray found later that a pure sample of mercuric hyponitrite could be readily prepared by the action of a concentrated solution of potassium cyanide on mercuric nitrite.

A pure sample of mercurous hyponitrite was obtained by precipitating (i) mercuroso-mercuric nitrite with crude alkaline hyponitrite and (ii) mercurous nitrate with carefully neutralised sodium hyponitrite. The mercurous hyponitrite dissolves in dilute nitric acid but the solution becomes opalescent on standing due to its dissociation into mercury and mercuric nitrite. On heating, mercurous hyponitrite decomposes. The main products of decomposition are mercury, mercuric oxide and oxides of nitrogen with small quantities of mercurous nitrite and nitrogen. This led Dr. Ray to conclude that while being heated only half of the mercurous hypo-nitrite exists in the oxylic form Hg. N: O, while the other half assumes the imidic structure Hg. O. N: N. O. Hg.

When the filtrate obtained after the treatment of a solution of mercurous nitrite with sodium chloride was treated with excess of ammonia, a white precipitate of a new salt, dimercuriammonium nitrate, $2NHg_2NO_2,H_2O$, was obtained. This opened up a new field for investigation and subsequently resulted in the preparation of a series of compounds known as dimercuriammonium compounds. On treating a solution of dimercuriammonium nitrite with HCl and HBr, Dr. Ray obtained another series of salts, mercuriammonium chloride and bromide: the latter on treatment with KOH gave dimercuriammonium chloride and bromide. But the action of nitric acid on $NHg_2NO_2,\frac{1}{2}H_2O$ directly gave dimercuriammonium nitrate identical with the compound obtained by the action of ammonia on mercuric nitrate.

Dr. Ray's work was now getting recognition. In order that Dr. Ray may come into touch with up-to-date methods of research the Government of Bengal deputed him, in 1904, to visit the chemical laboratories in Europe. During his short stay, he himself worked on the dimercuriammonium compounds at the Davy-Faraday laboratory and met a number of distinguished chemists in England and on the continent, chiefly Sir William Ramsay, James Dewar, Emil Fisher, van't Hoff and Berthelot who were pleased to take him round their laboratories and to explain to him the important work done by them.

On his return Dr. Ray started his investigation with redoubled vigour. Because of its unstability, all attempts to obtain mercuric nitrite in the solid state had hitherto resulted in failure. Dr. Ray set himself to work on the preparation of this unstable compound and

found that if equimolecular quantities of pure silver nitrite and mercuric chloride are rubbed together to a fine paste with water, a yellow solution is obtained and this on concentrating under vacuum over sulphuric acid yields tufts of fine needles of Hg $(NO_2)_2$. When the needles are exposed to air, they readily decompose but they could be kept as such indefinitely in completely evacuated sealed tubes. Dr. Ray had thus discovered a new technique for the preparation of mercuric nitrite and was naturally led to the preparation of such other nitrites which easily decompose on exposure to air. He, however, boiled the mixture of silver nitrite and the chloride of the base in the case of fairly stable nitrites. He thus prepared nitrites of the alkali metals and of metals of the alkaline earth, but later on he found it more convenient to use barium nitrite and the sulphate of the base for the preparation of the nitrites of other metals. In the same way by using silver nitrite and the hydrochloride of a number of alkyl, iso-alkyl, aryl and alkyl-aryl amines he succeeded in preparing their ammonium nitrites. But when he attempted to prepare these nitrites by using mercuric nitrite and alkyl and aryl amines, he not only obtained the alkyl and aryl ammonium nitrites but also a series of mercuri-alkyl and mercuri-alkyl-aryl ammonium nitrites.

Having obtained the various nitrites by the method of causing the substances to react by rubbing them together into paste with water, Dr. Ray extended the use of this method to the preparation of double nitrites of mercury with those of other metals. He thus obtained a series of mercuric alkali-metal and mercuric alkaline earth metal nitrites. Further he showed that these nitrites and the mercuri-alkyl and mercuri-aryl ammonium nitrites are complex and not the double salts, the mercury forming the complex anion and the alkali metals and metals of the alkaline earth the cation.

An attempt was then made to study some of the physical and chemical properties of these nitrites. He mainly studied their molecular volumes and the action of heat upon them. It was found that all nitrites decompose on heating. The decomposition products of the nitrites of alkali metals and those of alkaline earth were in general, oxides of nitrogen and a basic nitrate which on further heating broke up into oxygen and the oxide of the metal. But the alkyl and the aryl ammonium nitrites did not show any regularity in their behaviour on heating. In general they decomposed into nitrogen or oxides of nitrogen and some other alkyl and aryl compound depending upon the nature of the alkyl and the aryl group in a particular nitrite. Whilst Ray was in the midst of discovering new series of compounds he was called away from his work and had to proceed to Europe for the third time to represent the Calcutta University at the Congress of the

Universities of the Empire in 1912 at London. He made the best use of this opportunity by reading a paper on the vapour density of ammonium nitrite before the Chemical Society. Dr. Ray had previously discovered that contrary to text-book statements, ammonium nitrite could be obtained in a stable crystallized condition. When an aqueous solution of the salt is heated at 37-40^0 in vacuum only a small amount is decomposed and at 70^0 most of it sublimes unchanged. It created a mild sensation amongst the chemists when Dr. Ray presented the vapour density data, obtained with the assistance of Dr. N. R. Dhar, which showed that ammonium nitrite unlike ammonium chloride does not undergo dissociation.

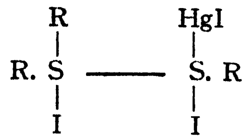
While in England, he received an invitation from Sir Asutosh Mukherjee, the Vice-Chancellor of the Calcutta University, to occupy the newly founded chair of chemistry at the University College of Science, Calcutta. He gladly accepted the offer and retired from the Presidency College in 1916 to take up the newly created Palit Professorship in Chemistry—the chair which he holds uptill to-day.

Dr. Ray's later work, carried during the years 1912–1916 at the Presidency College and from 1916 onwards at the laboratories of the Science college, forms a very important contribution to synthetic chemistry and the varying valency of certain metals. The method of preparing nitrites described in the previous pages was extended to the case of several other metals and cadmium, zinc and gadolinium nitrites were obtained. Also a series of alkaloidal derivatives of mercuric nitrite was prepared and the electrical conductivity measurements of aqueous solutions of some of them confirmed the previous conclusions that these are complex and not the double compounds. In a similar way a series of mercuri-alkyl and mercuri-alkylaryl-ammonium chlorides was obtained.

When mercuric nitrite was treated with mercaptans, nitromercaptan $R.S.HgNO_2$ and compounds of the type $R.S.HgNO_2,Hg(NO_2)_2$ were formed. Et $S.HgNO_2$ with ethyl iodide yields yellow tablets of $Et_2S_2.HgI_2.EtI$ which has been shown to be a sulphonium derivative, $SRR'I.SRI.HgI$.

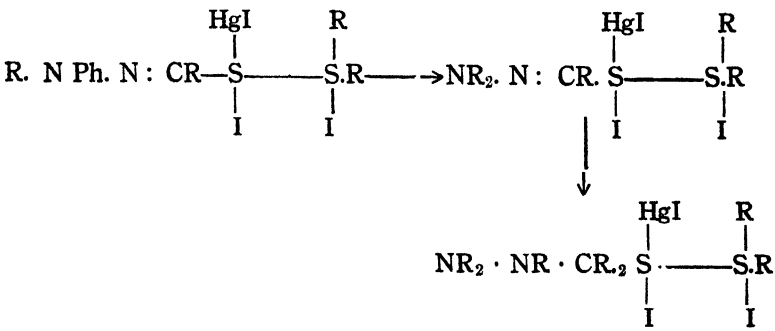
When mercury mercaptide nitrite was similarly treated with butyl iodide it was found that one of the methyl groups is replaced by the butyl, yielding $MeS_2.C_4H_9,HgI_2.C_4H_9I$. It was observed that, in general, the lighter radicals are invariably displaced by heavier ones. Later experiments, however, showed that the ethyl group could be replaced by methyl provided the methyl iodide is taken in large excess, the displacement of one group by another being governed by the Law of Mass Action.

Only two atoms of iodine of the sulphonium compound were found to be replaceable when its aqueous solution was treated with $AgNO_3$, for, as will be seen from the general formula,

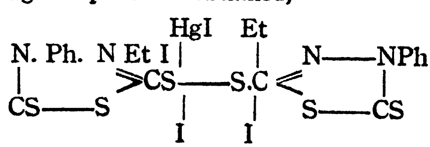


the third atom of iodine forms a part of the complex radical (HgI). However in acetone solutions, Dr. Ray found that all the three atoms of iodine are precipitated quantitatively by $AgNO_3$. He thus discovered a method of preparing a series of disulphonium compounds in which all the atoms of iodine are replaced by other acid radicals on treating the disulphonium iodide by an acetone solution of the silver salt of the radical.

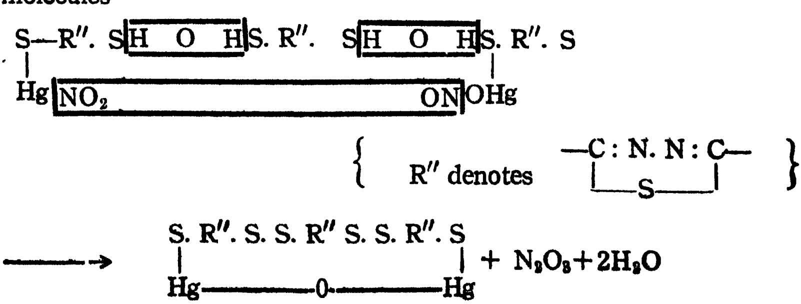
When 2-thio-3 phenyl-2: 3 dihydro-1: 3: 4 thiodiazole disulphide was treated with $HgNO_2$ and the resulting product allowed to react with alkyl iodide an open chain compound was obtained,



But if the reaction with ethyl iodide is carried out in carbon disulphide solution a ring compound is obtained,



When the dimercaptans of which 2:5-dithiol-1: 3: 4-thiodiazole is a typical example, are similarly treated with $HgNO_2$, the nitrous acid disengaged in the reaction, oxidises the hydrogen atoms of two or more molecules



and yields a closed chain sulphoxy compound. Alkyl iodides rupture the ring and compounds of the type

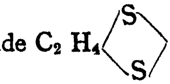
$$IHg—S—R''—S—S—R''—S—S—R''—S—HgI$$ are formed.

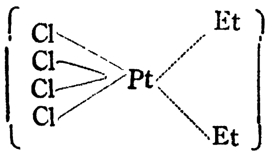
The K-atom of the potassium salts of the cyclic complex mono-mercaptides was found by Dr. Ray to be singularly reactive towards halogenated organic compounds. But the potassium salts of the dimercaptides were almost inert because two SK groups of these salts exercise an inhibitory influence. The reactivity is, however, greatly enhanced by the introduction of a negative group like (NO_2). The electrical conductivity data in acetone solutions showed that these di-sulphonium derivatives behave like true salts.

But while attempting to prepare the sulphonium derivatives of other metals by the method described above, Dr. Ray found that instead of $R_3S_2MI_3$, $R_3SI.MI_2$ and $2R_3SI.MI_2$ (where M = Cd or Zn) were invariably obtained. By modifying the conditions of the reaction he also succeeded in preparing the corresponding mercury compounds. From a comparison of these two types of compounds with $KHgI_3$ and K_2HgI_4 the structures R_3SMI_3 and $(R_3S)_2.\ MI_4$ were assigned to them. Antimony halide under similar conditions gave a number of complexes of the type SbX_3R_3SX and $(R_3S)_3.\ SbX_6$ (X = I, Br, or Cl and R = alkyl). On the other hand hydrochlor-auric acid, auric chloride and silver nitrate yielded additive compounds of the type $AuCl_3.R_2S$, $AuCl.\ R_2S$ $AgNO_3.R_2S$ and $AgNO_3.\ R_2S_2$.

Dr. Ray prepared another series of interesting compounds by passing steam for a very long time over a mixture of ethylene dibromide and potassium hydrogen sulphide. The milky distillate after the removal of alcohol and ethylene mercaptan solidified to a crystalline mass which was found to be triethylene trisulphide $(C_2H_4)_3S_3$—this formula being preferred because of the formation of the compound $(C_2H_4)_3S_2.\ PtCl_3$. The non-volatile oily residue was, on the other hand, found to be a mixture of three polymeric triethylene tetra-sulphides. By the action of mercuric nitrite and mercuric chloride on these sulphides, derivatives of the type $(C_2H_4)_3.S_3.2Hg\ (NO_2)_2$ and $(C_2H_4)_3S_3.3HgCl_2$ were obtained. The sulphides and their derivatives, on oxidation with $KMnO_4$ or dilute HNO_3, yielded various sulphones, sulphinic and sulphonic acid derivatives.

By the interaction of dithioethylene glycol and C_2H_4Br, 1: 4-dithian was prepared. The polymer of dithian obtained by Victor Meyer was found to be a mixture of brominated long chain compound. The compound, $Br.\ C_2H_4\ (SC_2H_4)_{48}Br$, found in the mixture was the first instance of crystalline organic sulphur compound having a very high molecular weight (3068).

In 1915, Dr. Ray had found that with platinic chloride, ethyl mercaptan yields under normal conditions chloroplatinum mercaptide $(Ets)_2.PtCl$ and under special conditions $(Et_2S)_2Pt$. Also dithio-ethylene glycol yields a chloromercaptide  Pt Cl. S. C_2H_4. SH. In all these compounds he showed that platinum acts as a tri- or divalent element and contrary to the views held by Reynolds, Prätorious-Seidler and Kurnaker, forms a part of the complex radical. On Werner's Co-ordination theory Dr. Ray represented the complexes $(Et_2S)_2$. $PtCl_4$ and $(Et_2S)_2.PtCl_2$ as



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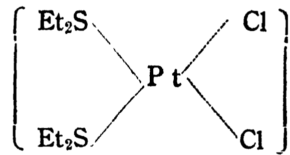
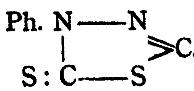


As expected from these constitutions the compounds were found to be non-electrolytes. A direct proof of the variability of valency of platinum was obtained from the study of the reaction between platinic chloride and (i) 2-thiol-5-thio-4-phenyl-4: 5-dihydro-1: 3: 4-thiodiazole



. SH and (ii) dithioethylene glycol $C_2H_4(SH)_2$. Using solutions of different concentrations and carrying out the reaction at different temperatures it was found that compounds Pt (S. C_2H_4. SH)x where $x = 3,4,5,6$ or 8, were obtained. At room temperature the hexa-compound was invariably formed; but at lower temperatures, the octa-compound and at higher temperatures, the tri-,tetra- and penta-compounds were obtained. Also when the reaction was conducted at room temperature with a dilute solution, the penta instead of the hexa-compound was formed. Thus Ray concluded that the valency of platinum is a function of temperature and the concentration of the reactants and explained the formation of these compounds on the kinetic theory of molecules.

In order to obtain further evidence for the varying valency of platinum Dr. Ray studied the action of ethyl and methyl sulphides on platinic chloride and obtained a series of compounds like $R_2S.PtCl$, $(R_2S)_2.PtCl_2$ (six isomers), $(R_2S)_2.PtCl_3$, $(R_2S)_2.PtCl_4$ and $(R_2S)_2.PtCl_5$, $2H_2O$, some of which were assigned constitutional formulae on Werner's theory. The above complex compounds when treated with ammonia and other organic bases yielded products which throw considerable light on the constitution of the parent bodies. All the six isomers of $(Et_2S)_2.PtCl_2$ gave the same product according to the following :—

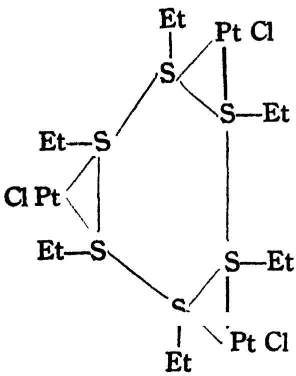
$$\left[\begin{matrix} Cl & & Et_2S \\ & >Pt< & \\ Cl & & Et_2S \end{matrix} \right] \xrightarrow{NH_3} \left[\begin{matrix} NH_3 & & NH_3 \\ & >Pt< & \\ NH_3 & & NH_3 \end{matrix} \right] Cl_2$$

The above reaction in which any organic base can be substituted for ammonia, shows that the alkyl sulphide can be exchanged by NH_3 and the organic base. But in a similar reaction with $(Et_2S)_2PtCl_3$, $PtCl_2$ $4NH_3$ was isolated from the reaction product and this indicated that it is not a co-ordination but a molecular compound of the structure

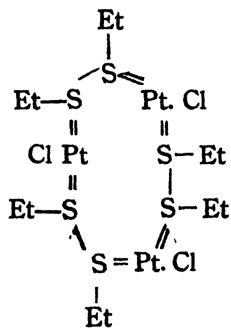
$$\left[(Et_2S)_2 \; Pt \; Cl_2\right].\left[(Et_2S)_2 \; Pt \; Cl_4\right].$$

Further, some compounds were prepared by the action of chloro-platinic acid on triethylene trisulphide and benzyl and methyl sulphides. These also confirmed the varying valency of platinum and the constitutions of some of them could be represented on Werner's theory while others were shown, by the reactions indicated above, to be molecular compounds.

In alcoholic solution some of the platinum compounds undergo polymerisation. Thus $Et_2S_2.PtCl$ polymerises into



or



in which case platinum again behaves either as a tri-or penta-valent element.

Gold was also found to exhibit similar variations in valency forming compounds with mercaptans and organic sulphides in which it acts as di-, tri,- tetra-and pentavalent element. $AuCl_3$ and Et_2S_2 gave a compound $2AuCl_2.Et_2S_2$ in which gold is divalent. The same halide reacts with monopotassium salt of dithioethylene glycol yielding a compound represented as

$$\overset{II}{Au} < \begin{matrix} S.\,C_2H_4.\,S \\ S.\,C_2\,H_4.\,S \end{matrix} > \overset{III}{Au}\,Cl \quad \text{or} \quad \begin{matrix} CH_2-S \\ | \\ CH_2-S \end{matrix} > Au < \begin{matrix} S-CH_2 \\ | \\ S-CH_2 \end{matrix} \quad Au\,Cl$$

Gold in these compounds behaves as di-, tri-or tetravalent element. If a similar reaction with sodium dithioethylene glycol be carried out in acetone solution, a pentavalent gold compound

$$\left[\begin{array}{l} CH_2-S \\ \;|\qquad\; > \\ CH_2-S \end{array}\right] \begin{array}{l} Au_2 \\ 5 \end{array}$$

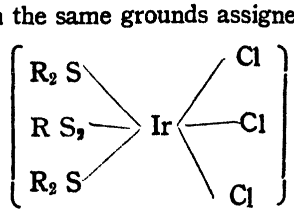
is obtained.

When benzal-diethylene trisulphide was similarly treated, compounds of the type $6R.Au_4Cl_3$; $5R.Au_3Cl_5$; $4R.Au_3Cl_4$; $4R.Au_3Cl_2$; $3R.Au_3Cl_2$; $3R.\,Au_2Cl_2$ (where $R = S{<}^{CH_2}_{CH_2}{>}S$, 1: 4-dithian) were obtained. Some of these compounds were shown to be sulphonium derivatives in which Au shows variable valency while others were found to be molecular compounds.

Similarly when iridium tetrachloride was treated with methyl, ethyl and diethyl sulphides it gave the compounds $IrCl_3.3Me_2S$, $IrCl_3.2Me_2S$, $Ir_2Cl_5.4Me_2S$, $IrCl_3.\ 3Et_2S$, $Ir_2Cl_5.\ 4Et_2S$ and $(IrCl_2).\ 3Et_2S_2$. This indicates that iridium like platinum and gold has also a variable valency. Iridium compounds were found by Ray to be much more stable than the corresponding platinum compounds. $IrCl_3.2Me_2S$ resisted all attempts to split up into $IrCl_2.2Me_2S$ and $IrCl_4.2Me_2S$ and was therefore represented as

$$\left[\begin{array}{ccc} Cl & & Me_2S \\ & {>}Ir{<} & \\ Cl & & Me_2S \end{array}\right] Cl$$

The compounds $IrCl_3.R_2S$ which have no platinum analogue (R = alkyl group) were on the same grounds assigned the structure



While Dr. Ray was preparing new series of interesting compounds he did not let the work on double salts which formed the starting point of his research career to be at all neglected. He prepared (i) double sulphates of the type $M''SO_4.\ (R_3S)_2.\ SO_4,XH_2O$ (where M''—Zn, Cd, Mg, Mn, Cu, Ni, Co, Fe), (ii) salts of the type (a) $X_2BeF_4,YSO_4,6H_2O$ which are isomorphous with double sulphates and fluoberyllates and (b) $MPO_3F.XH_2O$; MSO_4, $(NH_4)_2PO_3F,6H_2O$; and $(NH_4)_2PO_3F,Al_2(PO_3F)_3,24H_2O$ which are isomorphous with sulphates, double sulphates and alums, respectively. It will be seen that in the (b) class of compounds (PO_3F) radical behaves like SO_4.

This account of Dr. Ray's activities as an investigator shows what an enormous amount of research work (vide Bibliography at the end) has been published from his laboratory. Most of this work is the outcome of his great discovery of the mercurous and mercuric nitrites

for which Armstrong has rightly given him the name 'Master of Nitrites'. The earlier work was singly carried out by Prof. Ray but much of his later work has appeared jointly with students who from time to time took the degree of the Doctor of Science on the presentation of a thesis and some of them were the recepients of the Blue Ribbon of the Calcutta University—the Premchand Roychand Scholarship. Dr. Ray's first research scholar was Jatindra Nath Sen and prominent, among those who followed are Panchan Neogi, Atul Chandra Ganguli, Atul Chandra Ghose, Hamendra Kumar Sen, Jitendra Nath Rakshit, Rasik lal Datta, Nilratan Dhar, Manik Lal Dey, Janendra Chandra Ghosh, Prafulla Chandra Guha and N. Adhikary. Prof. Ray is equally proud of Janendra Nath Mukherjee, Satendra Nath Bose, Pulin Behari Sirkar, Meghnath Saha, Biman Behari Day, Prafulla Chandra Mitra, Priyadaranjan Ray, Janendra Nath Ray and Jogendra Chandra Bardhan who studied under him for their undergraduate courses. These scholars have distinguished themselves with their meritorious work, receiving international recognition, and most of them are to-day occupying the professorial chairs in several colleges and Universities in India.

Dr. Ray's activities were not merely confined to the experiments carried out in the chemical laboratory but his knowledge of chemistry led him to establish what is now known as the Bengal Chemical and Pharmaceutical Works Ltd. at Calcutta for the manufacture of drugs and chemicals. It is striking to find that these works which were started in a small house with a meagre capital of Rs. 800/-, are now spread over an area of 60 acres employing 2000 men and their present assets amount to half-a-crore of rupees. In this enterprise Dr. Ray was assisted by his friends, chiefly by Amulya Charan Bose and Satis Chandra Sinha in the early stages of the evolution of the works. To-day the various departments of the works are looked after by expert chemists who are Dr. Ray's students and they, under his able guidance, have succeeded in raising the works to their present status.

But while engaged in the laboratory work Dr. Ray devoted his time equally to studies. Being gifted with the art of writing, he has published several books on scientific subjects both in English and Bengali. His monumental publication is the History of Hindu Chemistry the first volume of which appeared in 1902 and the second one five years later. In these two volumes Dr. Ray has shown that Indian alchemy is of an indigenous origin: the ancient Hindus, for example, were acquainted with the processes of sublimation and distillation, could distinguish between mild and caustic alkalies and identify the metals by the colouration of the flame etc. These volumes won for him appreciation both from India and from other parts of the world. The book was reviewed in glowing words by eminent persons in most

of the Journals and papers in India and Europe. Berthelot remarked, 'A new and interesting chapter has been added to the History of Science and human thought.' The University of Durham conferred upon him the honorary degree of D. Sc. in 1912 chiefly in appreciation of the History of Hindu Chemistry.

In 1924 Dr. Ray with the assistance of Dr. J. N. Mukherji, Dr. J. C. Ghosh and Dr. S. S. Bhatnagar succeeded in laying the foundation of the Indian Chemical Society of which he is the foundation Fellow and a Patron. The Society elected him as its first president and availed of his vast experience and knowledge in guiding its working in its early life.

On account of his meritorious work and distinguished career Prof. Ray has been honoured from time to time both by the Government and the scientific organisations in India. The University of Calcutta conferred upon him the Honorary degree of Ph. D. in 1908. The Government of India honoured him with the title of C. I. E. in 1912 and with Knighthood in 1919. The Indian Science Congress elected him as its president in 1920 and various Universities in India invited him to deliver an address at their convocation meetings. H. E. Armstrong has remarked in an article to Nature "Our recognition of Ray's Services, as chemist, as teacher, as historian and as a founder of a great national school of scientific inquiry, is long overdue—it is nothing short of a reproach to our Royal Society that it should hitherto have been so narrow in its outlook as not to include his name in the roll of Fellowship."

Although Prof. Ray's life is full of activities of a scientific character it is noteworthy to find that he gave his fullest share to the activities outside the test-tube. He has been seen working energetically with the rescuers in times of floods and famines. Being a rationalist in his views, he has ever taken a keen interest in reforming the social shortcomings in communal and religious bodies.

Prof. Ray is a living embodiment of the maxim 'Plain living and high thinking'. Being a man of ascetic disposition he is ever ready to benevolently help the poor with his purse. His earnings as professor and gains from the Bengal Chemical and Pharmaceutical Works are spent on charities. Mr. Padmini Mohan Neogy writing about the philanthropy of Prof. Ray in the Indian World says, ". . . How often have we seen wretched young men, wretched on account of poverty, going up into his laboratory room where they laid bare their heavy bosoms, and he the father of them all, fondling with all the affection as though they were his own...." Like a true Guru, Acharya Ray, as he is usually called, has not only helped his students with money but has spent the best part of his life in training them. He considers these

young workers to be the richest treasure which he could bequeath to the scientific world.

Poor in health—dyspepsia and insomnia being his chronic complaints—Prof. Ray takes every day what he calls constitutional walks and is full of vigour. Besides devoting his time to other activities which are engaging his attention at present, Dr. Ray, now seventy-two years of age, still pursues his scientific researches and one can find a paper by him along with his pupil in the recent issues of the Journal of Indian Chemical Society. Let me end this short account of Dr. Ray's life—an account which is by no means an exhaustive one—with a prayer to the almighty "May he live long to inspire us with his example and precept."

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AN INDIAN HYGIENE MUSEUM

By

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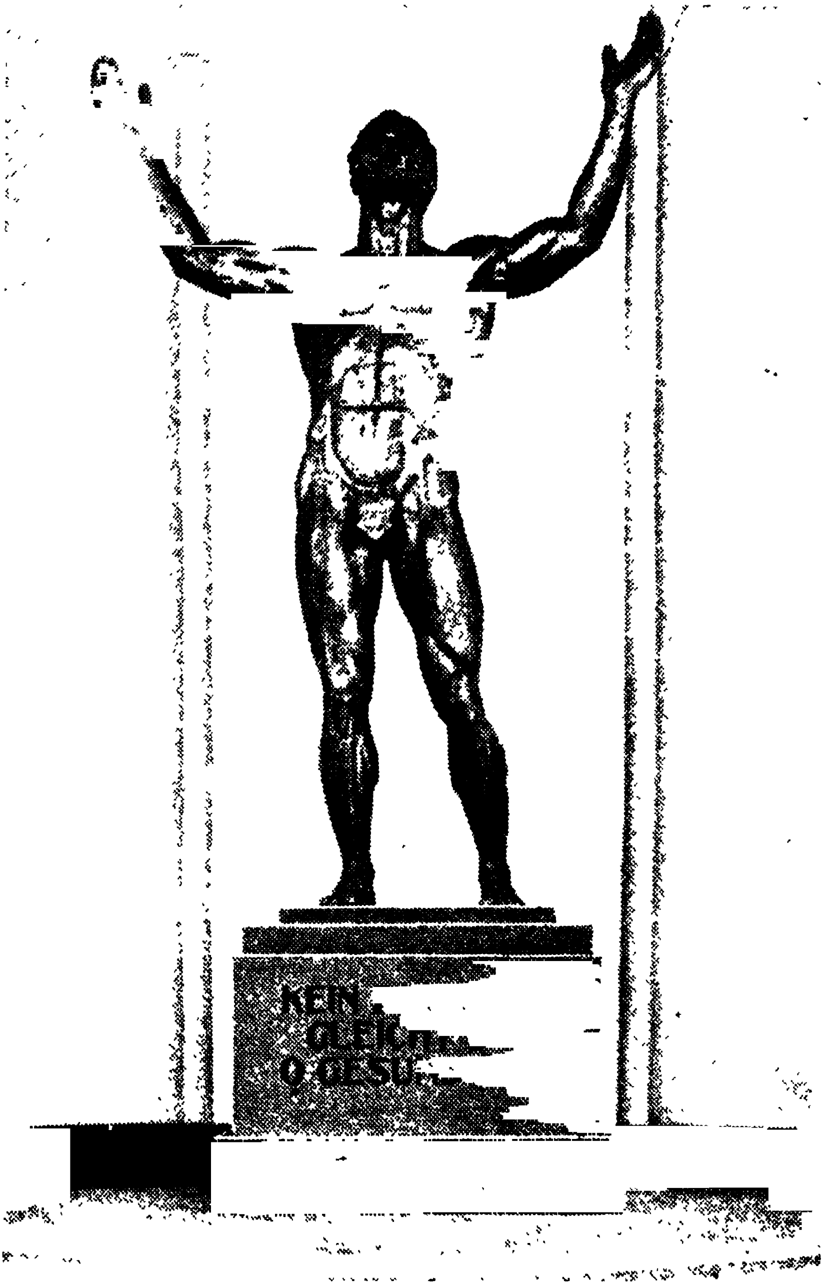
In one of those fateful years when the war clouds were already banking up on the horizon of Europe, the present writer found himself a member of a small executive committee charged with the task of collecting guarantees and donations towards a British pavilion at the great International Exhibition of Hygiene, which was then in course of erection at Dresden.

Great difficulties had been encountered in raising money for this British effort, owing in part to the strained political relations which even then existed between the British and German Governments. However, with the assistance of Sir Thomas Barlow, Physician to King Edward the Peacemaker, and his distinguished confrêre Sir Lauder Brunton, these difficulties were eventually overcome and a first rate Pavilion was erected in a prominent position in the exhibition grounds. In this building were set out valuable exhibits illustrating the progress of Hygiene and Medicine in Great Britain. Actually a surplus of funds was realised after paying all guarantors, these funds were devoted to the support of institutions concerned with health and physical development.

While the Exhibition was in progress the writer was privileged to visit it as a member of a deputation from the Corporation of Manchester, and to study those exhibits in which he was particularly interested. Among these, memory recalls pictures and models showing the progress of urban sanitation through the centuries, the dreadful filth of medieval towns being compared with the cleanliness and brightness of a modern city.

In the spacious hall entitled " Der Mensch " (Man) dominated by a great statue illustrating the physical ideal of *homo sapiens,* were grouped exhibits showing the perfect conditions to be observed from childhood to age, if this physical perfection was to be attained. In those days vitamins were not so much in the foreground, but food values and calories were amply illustrated. In other halls there were exhibits of a more medical nature and concerned less with health than with disease. The utility of these exhibits may perhaps be questioned, though their object no doubt was to warn by fear, if encouragement by the reward of health should be inadequate.



“ Der Mensch.”

Along these halls passed throughout the day, orderly crowds of simple studious people, many of them obviously from the countryside, and all of them absorbing earnestly in conscientious German fashion the education set before them.

With these memories in his mind, the author was surprised one day to note in "The Times of India" a paragraph describing a proposal for a Hygiene Museum for Bombay based on the Dresden model. He then learned that the Exhibition of 1911 had become a permanent national Museum and a centre from which help of every kind was willingly given, to those who might be engaged in similar activities elsewhere.

It was further learned that the prime mover in the Bombay scheme, Mr. G. M. Jadhav, was educated at the Manchester Grammar School, and afterwards became foreign language master there, where dreams and ideals of service had been born in him; altogether a strange coincidence. The original idea based on the Dresden model has been extended to include other subjects of general human interest following the plan of the great Museum at Munich which sets out to illustrate the activities of mankind through the ages.

It is now proposed to have not one, but eight Museums as follows :—

Indian Hygiene Museum.
Technology and Engineering Museum.
Museum for Sociology and Economics.
Museum for Agriculture.
Science Museum.
Evolution Museum.
Trade and Commerce Museum.
Geography and History Museum.

An excellent site has been earmarked on the new Back Bay Reclamation and it remains for all well-wishers of India to support the scheme by their interest, work, and financial generosity.

With his experience of the British Pavilion at Dresden in his mind, the writer cannot doubt that if the will is present, needful finance will be forthcoming.

Surely no object can be more worthy than the creation of a centre of enlightenment and mass education of the simple people of the new India which, in spite of politicians, is rapidly coming into being.

Anyone who has had charge in India of a Museum or even of Laboratories in which interesting and novel experiments are going forward will not need to be convinced of the appeal which teaching by the eye makes to ordinary folk of India. The writer must confess that he was sometimes concerned for the amenities of his bacteriological laboratory when it was invaded by happy families of sightseers,

who regardless of the dust of the highway which they brought with them, came in eager crowds from time to time within the sacred precincts.

Official reports from the Calcutta and Madras Museums confirm this eagerness for information on the part of the Indian masses.

The writer's recollection of the Ancoats Art Museum planted as it was in the most dingy and depressing quarter of Manchester, encourages him to believe in the even greater usefulness of the proposed Indian centre.

Just as the Dresden and Munich Museums send out inspiration and literature to all who desire them, so will these Museums in Bombay serve to feed smaller centres and thus spread enlightenment throughout the country.

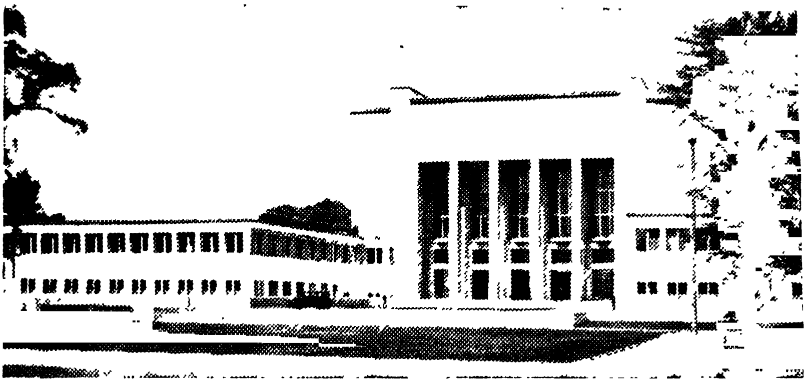
Already more than one energetic Director of Public Health is making use of Models and pictures of all kinds to educate the villagers during Health Weeks and other such public occasions.

With the coming of broadcasting, these exhibits and the cheap literature which it is also hoped to provide, can be explained in simple vernacular language to the rural population.

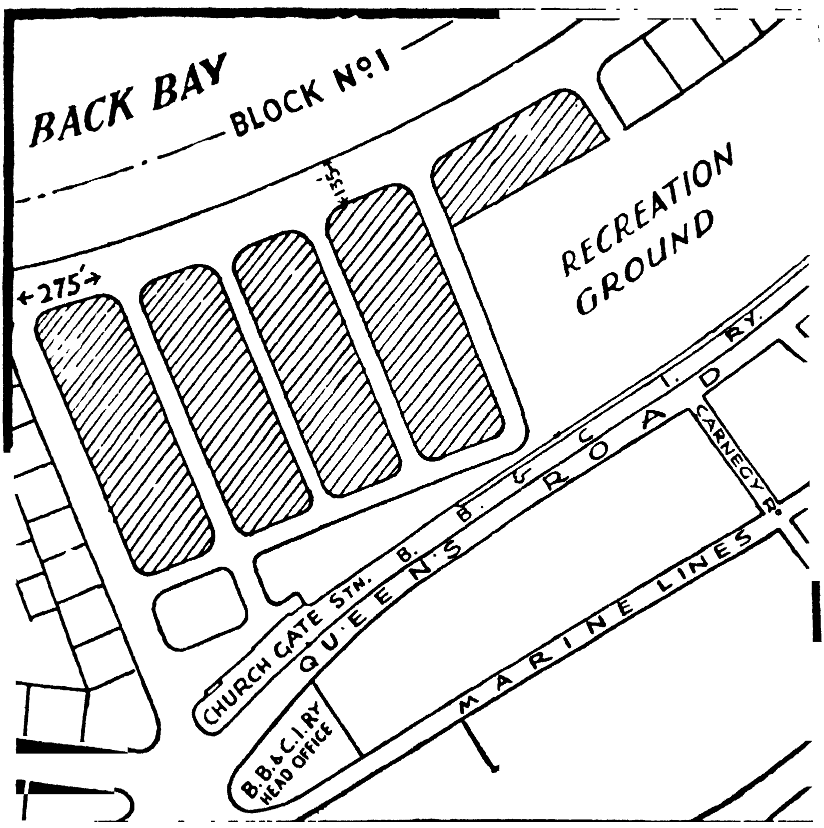
Already through the energy and idealism of the Honorary Secretary of the movement, Mr. G. M. Jadhav, a beginning has been made with the distribution of such literature.

Those interested can obtain pamphlets and other information which they may desire, from Mr. Jadhav at Parel, Bombay.

Surely this is an object in which all may unite without distinction of caste, creed or race and thus beyond its immediate objective the scheme will play a noble part in spreading the spirit of goodwill, which is the greatest need of India, and indeed of the whole world to-day.



General view of the German Hygiene Museum, Dresden.



The proposed site of the Museum in Bombay.

Summaries and Abstracts of M. Sc. Theses for 1932-1933.

1.—"*Some Biochemical Aspects of the Physiology of Sandal*" (*Santalum album* Linn). Being a part of the thesis submitted by MR. Y. V. SREENIVASA RAO, Department of Biochemistry, Indian Institute of Science, Bangalore, for the award of the Degree of Master of Science, University of Bombay.

Historical and general introduction.—A historical survey of the growth and spread of sandal in South India is given. The place of sandal in the economy of nature and its economic importance to India are indicated. It represents one of the few parasites which have an economic value.

PART I (A).—*Nature and extent of Parasitism of Sandal as revealed by Inorganic constituents.* The importance of the rôle of mineral nutrients in plant life has been described. The nature and extent of parasitism of sandal from this point of view has been studied.

Control cultures of sandal have established that (1) without a host, sandal continues to have a struggling existence, (2) some host plants are better suited to nourish sandal than others. It has also been found that if sandal is deprived of its host plants, either by removal or death of the latter, it ceases to put on any visible growth; the leaves turn pale and chlorotic in spite of the rich soil that may be provided. But if a host, more especially of the leguminous type, is reinstalled, the sandal starts growing again, in the course of two to three weeks, the pale yellow leaves turning green and the plant putting on a healthy appearance. Cultural experiments have revealed that sandal is largely dependent upon its host plants for its nitrogen and phosphorus requirements. It has also been found that sandal exhibits a preferential affinity to certain types of host plants, with regard to its haustorial attachments.

PART I (B).—*A Physico-and Biochemical study of the tissue Fluids of Sandal in Relation to the Associated host plant.*—It has been shown how the physico-chemical measurements and chemical composition of the tissue fluids of plants is receiving more and more attention at the present time from physiologists and pathologists.

Physical-chemical measurements of the tissue fluids of the leaves, stems and roots of sandal in association with its hosts, have

revealed that the osmotic pressure of the sandal is always greater than that of its host. This is in conformity with the results of Arthur Harris and J. V. Lawrence who have shown, in their work on the " Osmotic concentration of the tissue fluids of Jamaican Loranthaceae parasitic on various hosts," that the parasite has always a higher osmotic concentration than its host.

Analyses of pot-cultured sandal plants nourished by known hosts have shown that the host has a considerable influence on the composition of the sandal sap, thereby rendering the plant more or less open to insect attack. The practical value of this interesting fact is realised if attention is called to the officially accepted theory that insects are the natural vectors of " Spike." By a judicious choice of host plants it should be possible to control the composition of the sap in such a way as to render it distasteful or repulsive to those classes of insects reputed to be vectors of disease.

PART I (C).—*Nitrogen Metabolism of sandal with and without host plant.* Distribution of the nitrogen (in the water soluble portion) in the leaves of sandal with and without host plant has been studied. It is seen that, with the removal of the host plant, the green leaves turn yellow and the tree will have a struggling existence, and this indicates that nitrogen constitutes the limiting factor without which the parasite does not flourish. The total and the protein nitrogen decrease on removal of host plant due to the poor absorption of nitrogen directly from the soil.

The water soluble nitrogen increases due to proteoclastic degradation of the native proteins and the ammonia nitrogen is also higher due probably to deaminisation in the case of the sandal without host. A study of the distribution of the hexone bases, has shown that Arginine nitrogen is slightly but distinctly greater in sandal without host. The cystine content on sandal without host is very low. This is very significant in view of the fact that cystine is known to favour the formation and functioning of root hairs.

Distribution of the Hexone Bases in Healthy and Diseased Leaves of Sandal. An historical introduction of the spike-disease of sandal has been given from the time when it was first discovered by McCarthy in the year 1899 with a summary of the results so far obtained.

The distribution of the hexone bases in the healthy and spiked sandal leaves has been worked out by two entirely independent methods with a view to determine the nature of the metabolic disturbances which manifest themselves with the onset of the disease.

(i) Van Slyke method as modified by Plimmer and Rosedale (1925)

(ii) Kossel's silver-baryta method.

The fact that the histidine

fraction occurs in a high proportion is significant in view of its close structural relationship with the physiologically active histamine, which has been found to inhibit the growth and functioning of roots.

Carbon-Nitrogen Ratios in Healthy and Diseased Tissues of Sandal. A modified apparatus for the determination of total carbon in plant material by the wet combustion method has been described.

Carbon Nitrogen ratios in healthy and spiked sandal have been estimated with a view to ascertain whether there would be any disturbance in this (C/N) ratio with the onset of the disease when the reproductive activity of sandal is arrested. The results are somewhat erratic and no definite conclusions could be drawn. While in the case of partially spiked plant, the C/N ratio in the beginning is not altered very much.

II.—"*Proteins of Fenugreek*" (*Trigonella Foenum Graecum*). being a part of the thesis submitted by Mr. Y. V. SREENIVASA RAO, Department of Biochemistry, Indian Institute of Science, Bangalore, for the award of the degree of Master of Science, University of Bombay.

The globulin and albumin in fenugreek have been isolated and analysed. The globulin (fraction A) is characterised by a surprisingly high content of histidine which is about four and a half times the average amount contained in other related globulins obtained from leguminous seeds. In this respect the protein has a close relationship with the protamines and histamines which are characterised by a high content of the hexone bases. The albumin (fraction B.) appears to contain phosphorus and sulphur in the molecule. In this respect the composition of this fraction approaches the casein of milk.

III.—*Dilatometric Studies in Enzyme Action.* Being a summary of a part of the thesis submitted by Mr. H. B. SREERANGACHAR, Department of Biochemistry, Indian Institute of Science, Bangalore, for the award of the Degree of Master of Science, University of Bombay.

The kinetics of two closely allied enzyme-substrate systems have been studied in the dilatometer. The course of reaction has also been followed by an entirely chemical method. The possibility of employing this elegant method for a time course study of these two enzyme-substrate reactions has been established.

A new type of dilatometer has been described where the enzyme and the substrate could be mixed in the dilatometer itself, thereby facilitating an investigation of the changes from the beginning of the reaction. The kinetics of the reaction could simultaneously be followed. At lower concentrations of substrate the total contraction

brought about by the system is found to be proportional to the weight of the substrate present in the reaction mixture. The contraction in cubic centimetres due to the enzymic hydrolysis of a gram molecule of the substrate can be calculated and represents the contraction constant of the particular enzyme-substrate system. The experimental procedure has been described in full detail. Various sources of error affecting the determination have been carefully examined and the correction applied wherever found necessary. By adopting the above method, the contraction constants of two closely allied enzyme-substrate systems, urease-urea and arginase-arginine, have been found to be 24·13 and 5·02 respectively. The method has already been extended to a study of the contraction constants of sucrase-sucrose, emulsin-amygdalin, emulsin-arbutin and emulsin-salicin systems. The contraction constants for sucrase-sucrose and emulsin-salicin systems are 6·02 and 4·105 respectively. In the case of emulsin-amygdalin and emulsin-arbutin systems no volume change is observed during hydrolysis. The contraction constants for two closely related colloidal substrates—starch and glycogen—have been determined, employing four different sets of diastatic enzymes. The extent to which these substrates are hydrolysed by these enzymes is indicated by the dilatometric depressions which do not in some cases agree with the results obtained by the chemical and polarimetric methods. These discrepancies are discussed and further lines of work to elucidate them indicated. The usefulness of these constants in the dilatometric estimation of substrates in physiological fluids and protein hydrolysates is illustrated in Section VI. The fair agreement of values obtained by the two methods, dilatometric and titrimetric, is noteworthy. Limitations of the methods are also indicated.

IV.—*Studies in the Formation of Heartwood in Santalum Album Linn*, being a summary of a part of the thesis submitted by Mr. H. B. SREERANGACHAR, Department of Biochemistry, Indian Institute of Science, Bangalore, for the award of the Degree of Master of Science, University of Bombay.

The earlier part of the papers devoted to a discussion on the theories regarding the biogenesis of essential oils in plants. The views held regarding the physiological rôle of essential oils in the economy of plant life and the nature of the factors which are known to influence the formation of oils in plants are carefully considered. The rôle of inorganic constituents reputed to stimulate increased production of essential oils in plants is also discussed with special reference to sandal.

A study of the distribution of the inorganic and organic constituents between the sap and heart

wood of *Santalum Album* Linn, has been made. Heartwood formation is accompanied by a large deposition of alcohol soluble constituents, resins and the essential oil in the case of sandalwood. Evidence has also been obtained that the precursors of the sandalwood oil do exist in the sapwood in combination with organic acids as esters, which get easily hydrolysed to yield santalol, which constitutes the main constituent of the essential oil.

V.—*Studies in Enzymes.* Being a part of the thesis submitted by Mr. N. KESHAVA IYENGAR, Department of Biochemistry, Indian Institute of Science, Bangalore, for the award of the Degree of Master of Science, University of Bombay.

The thesis consists of two parts, the first dealing with a detailed study of the fungus inulinase and the second with a preliminary investigation of the respiratory enzymes of the leaves of sandal in health and disease.

Phosphates have been found to stimulate the formation and activation of inulinase in the fungus, from which the enzyme is extracted by simple leaching out with distilled water. The enzyme extract invariably represents a mixture of inulinase and invertase and a separation into their individual components has been attempted through adsorption on calcium hydrogen phosphate or inulin.

Purification of the enzyme has resulted in a product which is almost entirely free from nitrogen but phosphorus could not be eliminated during the process in spite of the most efficient methods, like electro-dialysis, employed for its purification. This has led to the suspicion that phosphorus is closely associated with Inulinase activity but further investigation on inulases from other sources is necessary before this can be finally confirmed.

The kinetics of inulinase action on Inulin has been followed in the two tubed dilatometer employing 0·25, 0·5 and 1·0 per cent. concentrations of substrate. The system yields a contraction constant of 3·68.

A new method of separating enzymes from their mixtures taking advantage of their differences in molecular weights and diffusion velocities in a centrifugal field, has been described. The method is capable of wide application and has been useful in separating inulinase from its associated invertase.

Employing Barcroft's differential monometric respiration apparatus, a study of the respiration of the leaves of sandal in health and disease has been conducted. Both tissues and tissue fluids have been used in the experiments. Diseased tissues exhibit poor respiratory activity and thus account for the accumulation of organic acids which characterises the spiked condition.

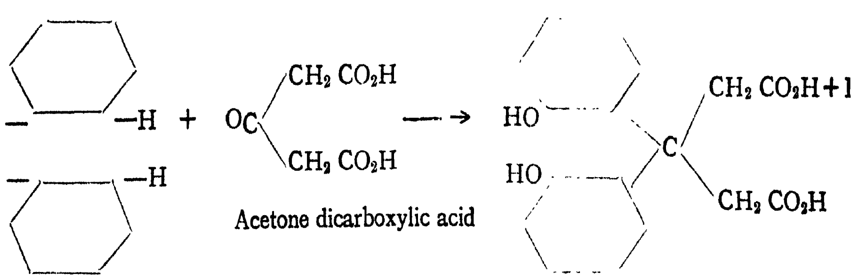
V. S.

VI.—*Condensation of Phenols and Phenolic Ethers with Acetone Dicarboxylic acid. Synthesis of ββ-substituted glutaric acids.* BY V. M. DIXIT and G. N. GOKHALE. Being a summary of Part I of the thesis submitted by Mr. Gokhale in October, 1932, for the M. Sc degree of the University of Bombay.

Acetone dicarboxylic acid has been condensed with phenols in the presence of various catalysers, the commonest amongst which is conc. sulphuric acid. [See:—*Coumarin-4-acetic acids* by Fries and Volk (Annalen, 1911, *379*, 90), Dey (Trans. Chem. Soc. 1915, *107*, 1606) Dey and Row (J. Ind. Chem. Soc. 1924, I, 110) and Limaye (J. Ind. Chem. Soc. 1927, *IV*, 159)]. *β-Substituted glutaconic acids* by Limaye and Dixit (vide Proc. Ind. Sc. Congress 1930, 167), Limaye and Bhave (J. Ind. Chem. Soc. 1931, *VIII*, 137) and Dixit (J. Ind. Chem. Soc. 1931, *VIII*, 787). The acetone dicarboxylic acid acts in the enolic form in these reactions.

A new compound was prepared by condensing phenols (2 mols) with acetone dicarboxylic acid (1 mol) in the presence of dilute sulphuric acid (75 p. c.). It was a crystalline dibasic acid (Formula:—$C_{17}H_{16}O_6$; Eq. Wt. 158 and M.P. 234^0) (with decomp) which formed insoluble copper and lead salts. Aqueous solution of the acid gave a bluish green coloration with ferric chloride. Similar new acids were obtained from o-cresol, quinol and p-cresylmethyl ether. Phenol gave the greatest yield.

The constitution of ββ-2: 2′ dihydroxydiphenyl glutaric acid is proposed for the new acid from phenol. The condensation is assumed to take place as follows:—

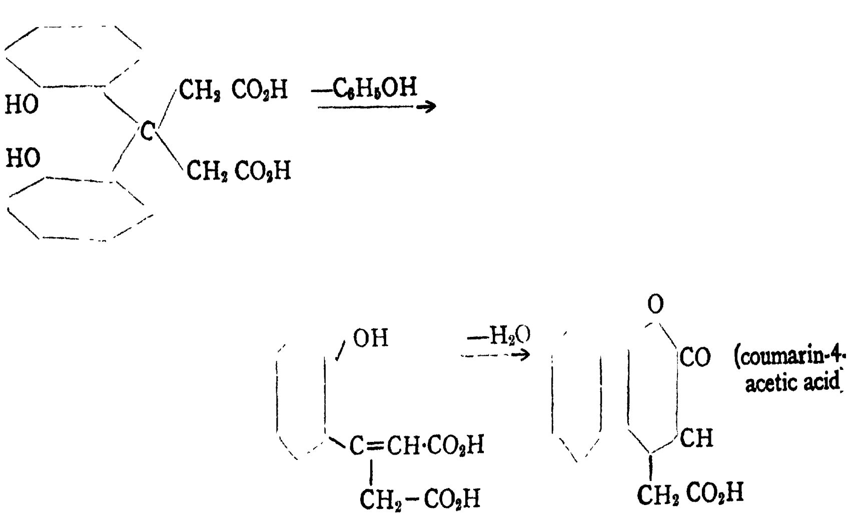


Phenol

ββ—2: 2′—Dihydroxydiphenyl-glutar

The acetone dicarboxylic acid acts in the ketonic form. The results of the following reactions bear out the given constitution :—

(1) Action of conc. sulphuric acid at 50^0-60^0 :—The compound breaks up almost quantitatively into coumarin-4-acetic acid, identical with that prepared by Limaye (loc. cit.) and phenol. The reaction is explained as :—

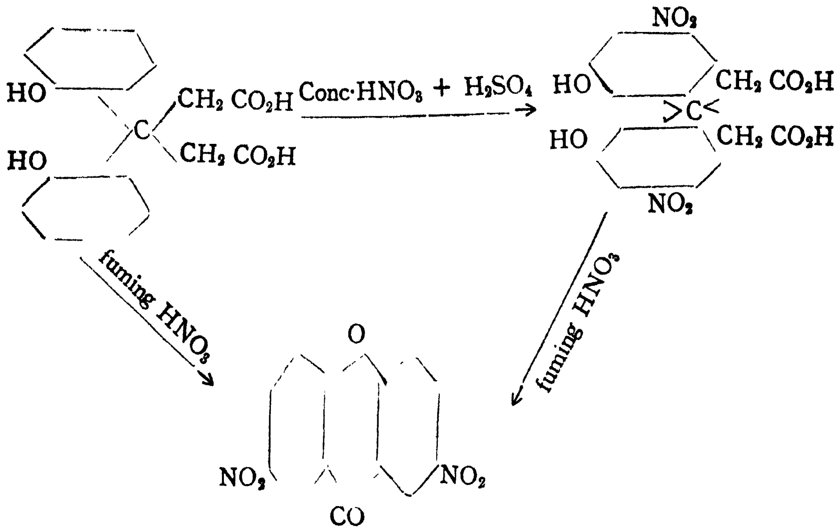


The intermediate glutaconic acid cannot be isolated [Dey, (loc. cit)] except in the decomposition of the corresponding glutaric acid obtained from p. cresyl-methyl-ether.

(2) Action of nitric acid :—On heating the new substance with conc. nitric acid in the presence of a small quantity of sulphuric acid in cold, a dinitro derivative was obtained.

Heating this dinitro derivative

or the original glutaric acid with fuming nitric acid in sealed tubes gave much of ββ-dinitroxanthone and a small quantity of picric acid. The reaction can be represented as :—



(3) Action of KOH :—Fusion of the glutaric acid with moist caustic potash at 180° gave 2 : 2′ dihydroxybenzophenone, identical with that obtained by Richter [J. Pr. Chem. 1883, (2) *28*, 285].

(4) Knoevenagel condensation :—Unlike the esters of coumarin-4-acetic acids, the ester of the new acid or the acid itself did not yield any condensation product with salycilic aldehyde in spite of several attempts with usual precautions.

(5) Synthetical reactions :—The dimethyl ester of the new glutaric acid formed the corresponding apocamphoric ester by condensing with dimethyl oxalate according to the method of Komppa (Trans. Chem. Soc. 1911, *99*, 2020) and it also condensed with dimethyl phthalate according to the method of Dieckmann (Ber. 1899, *32*, 2227).

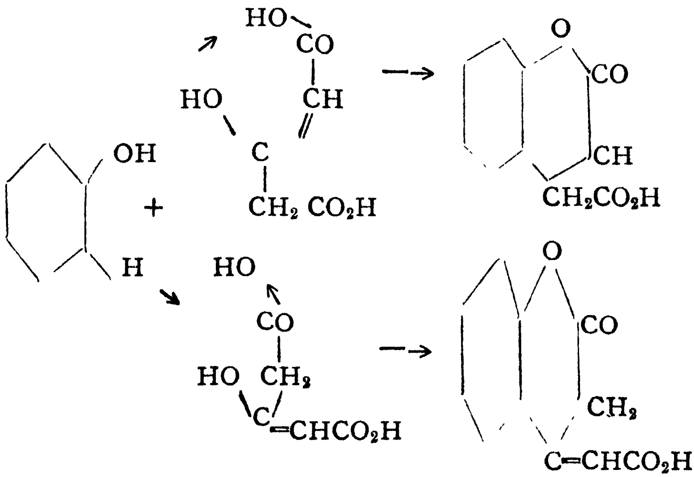
Besides these, the new glutaric acid formed a number of characteristic derivatives. The corresponding glutaric acids obtained by condensing acetone dicarboxylic-acid with o-cresol, quinol and p-cresylmethyl ether respectively showed analogous equivalent wts., analytical data, salts and behaviour with conc. sulphuric acid.

In converting the ββ-2 : 2′-dimethoxy-4 : 4′-methyl-phenyl glutaric acid, which is obtained from p-cresyl-methyl ether, into the corresponding 6-methylcoumarin-4-acetic acid by sulphuric acid, the intermediate β-2-methoxy-5-methylphenyl glutaconic acid was isolated. This on keeping in conc. sulphuric acid changed to the 6-methyl-coumarin-4-acetic acid.

The work is being continued.

VII.—*Condensation of phenols, with acetone dicarboxylic acid, Anhydrides of β-2-hydroxy-phenylglutaconic acids.* By V. M. DIXIT and G. N. GOKHALE.

Coumarin-4-acetic acids have been prepared by condensing phenols with acetone dicarboxylic acid, in the presence of conc. sulphuric acid. [See:—Dey (Trans. Chem. Soc. 1915, *107*, 1606). Dey and Row (J. Ind. Chem. Soc. 1924, *I*, 110), Limaye (J. Ind. Chem. Soc. 1927, *IV*, 159) and Dixit (J. Ind. Chem. Soc. 1931, *VIII*, 787)]. In some of his reactions, Dey has obtained tautomers (I and II) of the same coumarin-4-acetic acid supposed to be formed at the same time due to the two different ways in which the acetone dicarboxylic acid may act. The reaction is represented as follows:—



—(I)

—(II)

Transformation of (II) to (I) was supposed to take place in the process of crystallisation which invariably caused a considerable change in the melting points. The two forms had the same equivalent weight and analytical data and both produced the corresponding 4-methylcoumarin when heated at their m. pts. Other experimental evidence to show the existence of (II) has not been recorded and the conversion of (I) to (II) has not been carried out.

With the object of studying the reaction in details, phenol and the three cresols were condensed with acetone dicarboxylic acid on the lines described by Dey and Row (loc. cit.) as the results from this method and that of Dey (loc. cit.) were identical. The crude product of each of these reactions, when fractionally crystallised yielded two different compounds (A) and (B) which were partly transformed into one another on long exposure to air.

The substance (A) of lower m.pt.:—

(1) Crystallises in long needles soluble in hot water, dilute alcohol,

ether and in sodium bicarbonate solution with effervescence. The original compound is recovered on acidifying this solution.

(2) Does not give any coloration with ferric chloride and does not form any definite compound with (i) acetyl chloride or acetic anhydride, (ii) benzoyl chloride, and (iii) oxidation by chromic acid in cold.

(3) Yields almost theoretical quantity of 4-methyl-coumarin when heated at its melting point.

(4) Forms the solid ethyl ester which in turn condenses with salycilic aldehyde in the presence of piperidine to produce the corresponding dicoumaryl (see Dey and Row). In short the substance (A) agrees well with the corresponding coumarin-4-acetic acid, found in literature.

The substance (B) of higher melting point :—

(1) Crystallises in broad prismatic needles, insoluble in water and dilute alcohol; soluble in alcohol, acetone and chloroform. Insoluble in sodium bicarbonate unless being in contact with it for a long time.

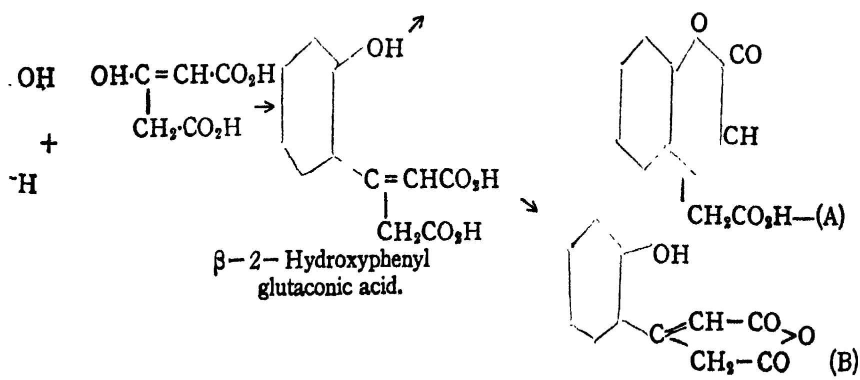
(2) Gives, in alcoholic solution, reddish coloration with ferric chloride.

(3) Can be titrated in alcoholic solution with alkali and has the same equivalent weight and analytical data as those of substance (B).

(4) Does not form an ester and does not condense with salycilic aldehyde under dry conditions.

The compound (A) can be converted into (B) by keeping it in contact with conc. sulphuric acid. The reverse change proceeds on hydrolysis of (B) by alkali.

The compound (B) is supposed to be the anhydride of the corresponding ortho substituted glutaconic acid, formed as follows :—



β-2-Hydroxyphenyl glutaconic acid.

The intermediate glutaconic acid is known to be incapable of free existence.

The following evidence is found in literature to justify this course of the condensation :- (1) β-substituted glutaconic acids have been prepared by condensing phenols and phenolic ethers with acetone dicarboxylic acid (See

Limaye and Bhave, J. Ind. Chem. Soc. 1931, *VIII*, 137. Dixit, J. Ind. Chem. Soc. 1931, *VIII*, 787 and Limaye and Gogate Proc. Ind. Sc. Congress 1932, 233). The corresponding coumarin -4- acetic acids were also found as by-products in these reactions.

(2) The substance (B) acts as a monobasic acid on account of its transformation into the " Hydroxy anhydride " due to the mobility of a hydrogen atom as explained by Thorpe [See Thorpe and Thole (Trans. Chem. Soc. 1911, *99*, 2187) and Thorpe and Bland (Trans. Chem. Soc. 1912, *101* 867)].

$$\mathrm{R-C}\!\begin{array}{l}\mathrm{CH-CO}\\ \mathrm{CH_2-CO}\end{array}\!\!>\!\mathrm{O} \rightleftharpoons \mathrm{R-C}\!\begin{array}{l}\mathrm{CH-CO}\\ \mathrm{CH=C-OH}\end{array}\!\!>\!\mathrm{O}$$

Normal anhydride — Hydroxy-anhydride.

The following experiments were further carried out with *the substance (B)*, and their results agree with the constitution assumed for it.

(1) Benzoylation :- Action of benzoyl chloride on the compound in solution with pyridine produces a neutral dibenzoyl derivative which is hydrolysed by alkali to the corresponding coumarin-4-acetic acid.

(2) Elimination of CO_2 :— By decomposing the dry compound under specially dry conditions, and reduced pressure, a phenolic substance results which sublimes and lowers the m. p. of the corresponding 4-methylcoumarin when mixed with it.

(3) Oxidation :—Oxidation of the substance in solution with acetic acid by chromic acid yields the corresponding ortho-hydroxy benzoic acid.

(4) Action of acetic anhydride in the presence of sodium acetate on the substance gives a crystalline acidic compound which is supposed to be formed according to the reaction described by Gabriel and Neumann (Ber. 1893, *26*, 951). The nature of this reaction is still under investigation.

The results obtained so far seem to indicate that the crystallisation of the crude product of higher m. p. into coumarin-4-acetic acid of lower m. p. as reported by Dey in some cases, may be due to the partial conversion of the substance of (B) type into that of (A) under those conditions.

Further work is in progress.

IX.—*Latent Instability in the Atmosphere revealed by some Indian Tephigrams.* By Miss M. M. PARANJPE, B. Sc.

By the application of the curve of saturation temperatures termed estegram (S. T. gram) suggested by Dr. C. W. B. Normand, for indicating humidity from the thermo-dynamic point of view, about 250 sounding balloon records over Agra, Poona and Hyderabad during 1929 to 1931 were examined from the point of view of latent instabi-

lity. Typical cases are described and limitation of the records on account of hair hygrometry considered. The conservative property of equivalent potential temperature is examined and in this connection a review is made of the various types of adiabatic diagrams and their bearing on equivalent potential temperature.

Sources of air samples relating to each individual record either exhibiting marked latent instability or no latent instability were investigated by tracing trajectories of upper air movement from the results of pilot balloon flights of the Indian net work of stations at various levels. Weather notes for all days of soundings bear out what would be expected namely that absence of latent instability is associated with dry, fine weather with occasional high clouds of non-convectional type and latent instability with convectional types of clouds like cumulus and cumulo-nimbus or rain or thunder or thunderstorms.

In general, marked latent instability is associated with incursions of oceanic air of tropical or equatorial origin having high equivalent potential temperature of the order of 340° to 350°A or more and decreasing with height; and that absence of latent instability is associated with continental air having relatively low E. P. T. of the order of 320–330°A increasing or remaining approximately constant with height. From the general circulation of upper air currents over India, this explains the comparative scarcity of latent instability in the winter both at Agra and Poona and Hyderabad as contrasted with the remaining part of the year.

X.—*Studies in Ferric Hydroxide Sol.* By S. K. BORKAR and B. N. DESAI.

Measurement of charge on ferric hydroxide sol has been carried out under various conditions *e.g.*, with progress of dialysis, in presence of electrolytes, from the point of view of critical potential, with progress of dialysis and with different dilutions. Simultaneous measurements of charge and viscosity with progress of dialysis have also been made.

It is found that with progress of dialysis the charge first increases, reaches a maximum, and then decreases. The stability is found to decrease continuously. There is an initial increase in charge on the addition of small quantities of electrolytes such as HCl, KCl and $FeCl_3$. It is also found that various samples of the sol coagulate at the same value of the charge—the critical charge-except in the case of HCl where the value is slightly higher.

On dilution it is found that sols dialysed for a period shorter than what corresponds to the maximum in the cataphoretic speed-dialysis curve, behave in one fashion; while those that are dialysed for a longer period behave differently.

Measurements on viscosity and charge show that neither the view

of Dhar (smaller viscosity, smaller hydration and greater charge ; and greater viscosity, greater hydration and smaller charge) nor of Smoluchowski (greater charge, greater viscosity ; and smaller charge, smaller viscosity) can individually explain the results.

XI.—*Action of Nitric Acid on Tin.* By G. S. KASBEKAR and A. R. NORMAND.

The reaction between tin and nitric acid under varying conditions has been studied by estimating all the products formed during the reaction, whether in the dissolved or in the gaseous state. It has been shown that during the above reaction in addition to the formation of stannous and stannic salts, hydroxylamine, ammonia, nitric oxide, nitrous oxide and nitrogen are formed. Neither nitrous acid nor hydrazine were formed under the conditions studied. The effect of various catalysts on the reaction was also studied.

It has been pointed out that the variations in the stannic tin and the gaseous reduction products of excess nitric acid go hand in hand, whereas the variations of stannous tin in solution are similar to the variation of the reduction products in solution, namely hydroxylamine etc.

In an attempt to explain the reduction of excess nitric acid not only has it been shown that nascent hydrogen could be the probable reducing agent, but it has further been suggested that the nascent hydrogen produced by the dissolution of tin in nitric acid may be of two different activities, the dissolution of tin to the stannous condition producing hydrogen of one activity while the dissolution of tin to the stannic condition producing hydrogen of a different activity.

XII.—*Studies in Solubility.* By P. G. DESAI and A. M. PATEL.

Part. I. Effect of polar and non-polar solvents on the solubilities of some organic acids.

The solubilities of benzoic, cinnamic, salicylic, phthalic and succinic acids have been determined in polar and non-polar solvents. In the case of non-polar solvents, the solvent action decreases with the increase in the polarity of the solute, the solubilities of phthalic and succinic acids being negligible in these solvents. The order of solubility is in accordance with the polarity of the solvents in case of slightly polar solvents, while in case of more polar solvents, the order is not well defined. Ideal solubilities of benzoic, cinnamic and salicylic acids are approached in ethyl alcohol, while those of the more polar phthalic and succinic acids are approached in methyl alcohol. Chloroform and acetone behave abnormally. It has been inferred from the solubilities of acids in water, nitrobenzene and alcohols that, benzoic cinnamic and salicylic acids form loose alcoholates with the solvents,

while succinic and phthalic acids form hydrates with water.

Part II. The solubilities of benzoic and salicylic acids in mixtures of solvents.

The solubilities of the two acids were determined in a number of binary mixtures. It is found that when both the components of the mixtures are non-polar, the solubility-composition curves are almost straight lines, whereas in case of mixtures of chloroform with aromatic hydrocarbons, the curves are convex towards the composition axis. In case of mixtures of acetone with non-polar liquids, the curves are concave towards the composition axis. In case of mixture of alcohols with non polar liquids and with nitrobenzene, the solubility increases, reaches the maximum and then decreases. The same is the case with mixture of nitrobenzene with the non-polar solvents. The results have been explained on the basis of association and de-association of molecules of the solvents when in presence of one another.

Part III. Relation between adsorption and solubility.

The adsorption of benzoic acid by animal charcoal, from mixture of (i) two non-polar, (ii) polar and non-polar and (iii) two polar solvents was determined. Adsorptions from non-polar liquids is greater than that from polar liquids. It is found that an inverse relation exists between solubility and adsorption. In case (i), the adsorption-composition curves are almost straight lines; while in the two remaining cases, minima are generally obtained on the adsorption-composition curves. It has been shown that in most cases where maxima are obtained on the solubility-composition curves, minima are obtained on the adsorption-composition curves.

Part IV. Viscosities of binary mixtures.

The viscosities of the mixtures of (i) two non-polar, (ii) two polar (iii) polar and non-polar liquids have been determined. It has been shown that in case of first type, almost straight lines with slight sagging are obtained. In mixtures of second type, viscosity-composition curves are convex to the composition axis with a minimum point in the case of n-propyl alcohol-nitrobenzene system. In case of the third type, the curves are convex to the composition axis, with a minimum in the case of benzene n-propyl alcohol system. An attempt has been made to relate viscosity-composition curves to the solubility-composition curves.

XIII.—*The Action of Acetic Anhydride and Sodium Acetate on the Anhydrides of β-Glutaconic Acids : The formation of β-Aryl-Acetic Acids with an Addendum.* By VISHNU MAHADEO BHAVE, M. Sc.

Being the summary of a thesis submitted in June 1932 from the Ranade Industrial and Economic Institute, Poona (4).

(1) By the action of acetic anhydride and sodium acetate on

the anhydrides of β-aryl-glutaconic acids, enolic forms of the β-aryl-glutaconyl-acetic acids of the general structure,

$$R.\,C\begin{array}{l}\diagup CH-C=CH.\,COOH \\ \\ \diagdown CH=COH\end{array}\! \qquad\qquad\qquad >O \quad ,$$

have been prepared for the first time,

[R = (a) anisyl, (b) phenyl, (c) methoxy orthocresyl, (d) methoxy para-cresyl, (e) methoxy meta-cresyl, and (f) ortho-methoxy-phenyl].

(2) Their constitution has been determined by the isolation of the corresponding methylene-glutaconides

$$R-C\begin{array}{l}\diagup CH.\,C=CH_2 \\ \\ \diagdown CH_2.\,\;CO\end{array} >O\ ,$$

β-aryl-γ-aceto-vinylacetic acids

$$R-C\begin{array}{l}\diagup CH.\,CO.\,CH_3 \\ \\ \diagdown CH_2\,COOH\end{array}$$

, arylidene ketones

$$R-C\begin{array}{l}\diagup CH.\,CO.\,CH_3 \\ \\ \diagdown CH_3\end{array}$$

and β-aryl-γ-aceto-butyric acids,

$$R-CH\begin{array}{l}\diagup CH_2\,CO.\,CH_3 \\ \\ \diagdown CH_2.\,COOH\end{array} .$$

(3) A parallelism between this reaction and the Gabriel's extension of Perkin's reaction to Phthalic anhydride has been established.

(4) The 'enolic' or 'hydroxy' glutaconyl-acetic acids have been converted into their 'keto' or 'normal' forms

$$R-C\begin{array}{l}\diagup CH.\,C=CH-COOH \\ \\ \diagdown CH_2\,CO\end{array} >O,$$

thus incidentally confirming Thorpe's view that glutaconic anhydrides exist in the 'enol' i.e., the hydroxy pyrone form.

(5) The reaction has been tried, on the hydroxy anils of aryl-glutaconic acids,

$$R-C\begin{array}{l}\diagup CH.\,CO \\ \\ \diagdown CH=COH\end{array} >N-C_6H_5.$$

(6) It has been suggested that the possibility of the condensation of acetic acid with β-aryl-glutaconic anhydrides may be due to conjugation.

(7) The *addendum* consists of a continuation of the work published in the Journal of The Indian Chemical Society, *1931*, 8. 137, by Limaye and Bhave, and the β-(4-methoxy-phenyl)-and β-(4-methoxy-3-methyl-phenyl)-glutaconic acids have been studied in more detail.

(8) Many functional derivatives like esters, semicarbazones, oximes, anilides, benzoyl-derivatives etc., of the main products have been prepared (in all some 90 new substances).

D. B. L.

XIV.—*Study of the pectic changes in the potato tubers at different stages of growth and in storage.* By S. D. AGNIHOTRI. (Dept. of Botany, Royal Institute of Science, Bombay.)

The study of the pectic changes in potatoes at different stages of growth, maturity and of senescence during storage is undertaken as it appeared from the survey of the literature on the pectic constituents of fruits and other plant-

organs that the softening of the tissue and its ultimate decay was due to the pectic changes occurring in them. The problem of potato storage is of economic importance in Western India and in spite of the efforts of the various workers there is no unanimity of opinion about the causes of decay of potatoes when stored during the summer months.

The method of Caree and Nanji modified slightly for the needs of this investigation for extracting and estimating different pectic constituents are employed. The free soluble pectin, protopectin, middle lamella pectin, and total pectic materials are determined and expressed as calcium pectate number for the tubers at different stages of growth and at short intervals after storage till the tubers are completely rotted.

The free soluble pectin, protopectin, middle lamella pectin and total pectins begin to rise as growth proceeds and the increases become smaller at maturity.

The free soluble pectin increases and the other three pectic constituents decrease as the age advances, and as the rotting sets in.

The downgrade changes begin to occur in storage conditions and they are responsible for the softening of the tissue which is caused by the separation of the cells due to loss of insoluble proto-pectin, and middle lamella pectin from the cell walls. The bacteria and other organisms get a footing as it were when the tissues soften and hasten the rotting of the tubers.

The study of the effect of temperature on the pectic changes in mature tubers shows that the downgrade changes are much accelerated as compared to the similar changes in tubers stored at room temperatures.

All tubers pass through the same sequence of pectic changes and during the hot weather they are, like all chemical reactions, accelerated.

The practical side of the potato storage is discussed in view of the results obtained and the lines on which further investigation should be undertaken are indicated.

XV.—*The Kinetics of Heterogeneous Organic Reactions: A study of the Benzoin Reaction.* BY D. R. NADKARNI, B. SC., Royal Institute of Science, Bombay.

It is not clear from the literature whether potassium cyanide and benzaldehyde in the absence of any other substances can yield benzoin. It has now been shown that pure benzaldehyde and pure potassium cyanide can yield benzoin but the reaction is readily inhibited by substances such as quinol and alkali halides, which are also negative catalysts in the oxidation of benzaldehyde. The conflicting results in the literature have thus been traced to their source, as the alkali halides are likely impurities in potassium cyanide. The kinetics of this reaction have been

studied at 100°C and at room temperature, and may be represented by the following equation:

Rate of formation of benzoin = $K_1 [C_6 H_5 CHO]^2 [\text{benzoin}] + K_2 [KCN] [C_6 H_5 CHO]^2$. It is suggested that two reactions take place:

(a) A homogeneous reaction between a trace of potassium cyanide dissolved in benzaldehyde. This reaction is autocatalytic and is not affected by inhibitors in the same manner as the heterogeneous reaction.

(b) A heterogeneous reaction between solid cyanide and benzaldehyde, the cyano-ion on the surface of the crystalline cyanide being effective in bringing about the reaction. This reaction is inhibited by the negative catalysts which are adsorbed on the surface of the solid cyanide.

The kinetics of the reaction in presence of water have also been investigated. The rate of the homogeneous reaction is unaffected but the reaction with solid cyanide is replaced by reaction with cyano-ions. This heterogeneous reaction between the dissolved cyanide and benzaldehyde is more rapid than that with anhydrous cyanide.

As the quantity of water is increased the dissolved cyanide is extracted from benzaldehyde and the homogeneous reaction ceases.

Inhibitors act in presence of water but their effect is greatly reduced. In fact water is decidedly a catalyst for the reaction probably because it induces the formation of a cyano-ion.

Current theories of the benzoin reaction which have assumed that the presence of water is essential for it to proceed are discussed in the light of the above results. It is pointed out that under anhydrous conditions the potassium cyanohydrin compound itself reacts whereas in presence of water the cyano-ion brings about the reaction.

The necessity for the presence of benzoin before the homogeneous reaction can proceed may be explained by the following series of equations:

1. $C_6H_5CHO + KCN = C_6H_5CH(OK)CN$.
2. $C_6H_5CH(OK)CN + C_6H_5CHO = C_6H_5C(OK)(CN)CHOH.C_6H_5$.
3. $C_6H_5C(OK)(CN)CHOH.C_6H_5 + C_6H_5CO{\cdot}CHOH\ C_6H_5 = 2C_6H_5CO{\cdot}CHOH{\cdot}C_6H_5 + KCN$.

S. M. and D. N.

XVI.—*Cellulose from rice straw.*

By B. B. SARDESHPANDE.

This work was undertaken to work out proper data pertaining to the yields of cellulose from Bombay rice straw under various conditions of alkali concentration, temperature and time of digestion and to find out whether it is possible to prepare paper and allied products from the cellulose obtained from Bombay rice straw.

The investigation has shown that Bombay rice straw contains 48 to 55% total celluloses. Out of these 34 to 37% is alpha cellulose and the rest beta and gamma celluloses. In actual mill practice,

therefore, the yield of cellulose from Bombay rice straw should be about 36 to 37%. To produce good quality of cellulose the straw should be digested in 3% alkali solution at 140°C for 1½ hours. Total alkali required for complete digestion of the straw is 10.5%. Total amount of bleaching powder required for the bleaching of the cellulose is 4.5% calculated as $CaOCl_2$. The fibres of rice straw resemble those of esparto in many respects. As the fibres of rice straw are shorter in length they have to be mixed with a small percentage of cellulose with longer fibres for ordinary paper manufacture. Samples of paper have been prepared from the cellulose obtained during the investigation and these have been favourably reported upon by paper makers.

M. S. P.

XVII.—*Starch and oil from Jowar.* By K. P. SHAH.

This work was undertaken to find out a suitable process for the extraction of starch from Jowar and to study the properties of the starch and the nature of the bye-products.

The investigation has shown that sulphurous acid process is a most suitable one for producing starch from Jowar. The yield of the starch by this process is 52% of the total weight of Jowar taken. It was found difficult to separate the germs completely from the grain by floatation. It is therefore necessary to work out some other process for the separation of the terms. The gelatinisation temperature of jowar starch has been found to be 67°C. Jowar starch granules are polygonal in shape and larger in size than those of the maize and rice starch. The starch gives a good paste without any grit and acted as a good binding material for the size. The starch gets desized very easily. The viscosity measurements showed that jowar starch resembled wheat starch in its place forming qualities. The waste bran obtained after separation of starch from jowar contains about 11% protein matter. The oil obtained from the germs of the jowar grain is a semidrying oil resembling maize oil in its properties. It had the following analytical characteristics :—Colour, Golden yellow ; Solidifying point 8° to 9°C ; Specific gravity 0·910 at 28°C ; Refractive Index 1·467 at 28°C ; Sap. value 173·2 ; Iodine value 126·8 ; Unsaponifiable matter 7·9% ; Iodine value of the mixed fatty acids 130 ; Neutralisation value of the mixed fatty acids 166·5 ; Sap. of the mixed fatty acids 186·1.

M. S. P.

XVIII.—*Hydrogenation of Common Indian oils.* By B. S. KANVINDE for the M. Sc. degree of the University of Bombay.

This work was undertaken to work out a suitable data for the manufacture of tallow substitute from vegetable oils by studying the

hydrogenation of Indian oils treated alone or in mixture in various proportions.

Ground oil, linseed oil, castor oil cocoanut oil and cotton seed oil were hydrogenated under various conditions of catalytic concentration using both supported and unsupported catalyst. From the results obtained it has been found that a mixture of groundnut oil (pea-nut oil) cocoanut oil and castor oil in a definite proportion will give on hydrogenation a product which has almost the same physical and chemical characteristics as the animal tallow. The investigation has further shown that the temperature of reduction has considerable influence on the activity of the supported catalyst. The melting point of groundnut oil at any particular degree of hydrogenation is the same irrespective of the nature and concentration of the catalyst used during the hydrogenation. Mixture of oils consisting of glycerides having similar constitution have in general a mean course of behaviour during hydrogenation in relation to individual oils.

M. S. P.

XIX.—*The Photo-reduction of Ferric Chloride in Alcoholic Solutions*: By P. S. LIMAYE B. Sc., The Royal Institute of Science.

The photo-reduction of ferric chloride in alcoholic solutions has been studied in sunlight and in artificial light. It has been found that in both the cases the reduction takes place in two stages: the order of the reduction in the first stage in the two cases is zero molecular. But in the second stage it is unimolecular in the sunlight and zero molecular in the artificial light. The extinction coefficient measurements of the solutions exposed to artificial light also show a sudden decrease in value after sometime. The change in the stage of the reduction from the first to the second in the above case is not due to the formation of colloidal ferric hydroxide as it has been found to retard the reduction in both the stages. The conductivity of solutions of ferric chloride exposed to sunlight also indicates that a change in the mode of reduction takes place sometimes after the exposure. The results are explained on the assumption that molecular species containing ferric ions are formed and they bring about the change in the mode of the reaction.

The quantum efficiency for solutions of concentrations between 0.1 M and 0.2 M lies between 1 and 3 at 30° for radiations lying in the visible region and it increases with (i) temperature, (ii) concentration of the solution and (iii) frequency of the incident light.

S. M.

XX.—*Studies in Titanium Dioxide Sol.* By MISS OLIVE JOSEPH B. Sc., The Royal Institute of Science.

The coagulation of the titanium dioxide sol by sodium and magnesium chlorides has been followed by the thermopile method during the progress of the dialysis of the sol. The coagulation velocity curves are 'S' shaped for sols dialysed up to ten days; sols dialysed for longer time do not show the autocatalytic nature of the coagulation process. Smoluchowski's equation applies to the coagulation of the titanium dioxide sol for only a limited range of the concentration of the coagulator.

The changes in the viscosity of the sol, dialysed and diluted to different extent, are measured with the progress of time when the sol is coagulated by mono, di and trivalent electrolytes and mixtures of these electrolytes with non-electrolytes (methyl, ethyl and n-propyl alcohols). In each case the viscosity increases to a maximum value and then begins to decrease. With electrolytes alone the time-viscosity curves are straight rising ones but in the presence of alcohols which exert peptising influence, these curves are 'S' shaped.

S. M.

XXI.—*Studies in Ceric Hydroxide Sol.* By M. V. NABAR B.Sc., Royal Institute of Science.

The coagulation of the ceric hydroxide sol, dialysed and diluted to different extent, has been studied when the sol is coagulated by sodium and magnesium chlorides and by a mixture of sodium chloride with alcohols (methyl, propyl and amyl) and solutions of sugars (cane sugar and glucose). The coagulation velocity curves are 'S' shaped for impure and the concentrated sols and steep for those diluted and dialysed for a long time. Smoluchowski's equation applies to the coagulation of the ceric hydroxide sol up to a limited range of the concentration of the coagulator. The alcohols sensitise and the sugars protect the coagulation of the sol by electrolytes: these actions increase as the sol gets purer. The sensitising action of alcohols increases as

$CH_3OH > C_3H_7OH > C_5H_{11}OH$.

Cane sugar and glucose act as protecting agents and the protective action of cane sugar is greater than that of glucose.

S. M.

XXII.—*Studies in Cobaltous Oxide.* By T. S. SURATKAR B. Sc., Royal Institute of Science.

(A) It has been shown that cobaltous oxide can be prepared by heating the cobalt carbonate under vacuum to 670° but the oxide obtained at higher temperatures shows a tendency to dissociate. On exposure to air the oxides adsorb oxygen and darken in colour. They contain active oxygen whose quantity decreases as the temperature of the preparation is raised. The colour of the oxide changes from yellow to brown, its density increases and the catalytic activity decreases as the

temperature of the preparation is raised but the solubility in sulphuric and hydrochloric acids is not much affected.

If the oxide is heated at a particular temperature for a long time then it does not show any tendency to dissociate and the composition of the oxide approximates more and more to the formula CoO. The stability of the oxide also increases on increasing the duration of heating, so much so that the sample of the oxide obtained at 900° does not change even on keeping for two months. Also the density, the solubility in sulphuric acid and the catalytic activity for the decomposition of hydrogen peroxide decrease considerably on increasing the duration of heating.

(B) The action of sulphuric acid on the mixtures of the cobaltous and copper oxides and the mixed oxides obtained on heating the mixtures of the cobalt and copper carbonates has been studied. The results obtained have been explained on the assumption that the mixed oxide is a mixture of copper and cobalt oxides when the mixed carbonates are heated up to 700° but the samples obtained at higher temperatures may contain Cu_2O, Co_2O_3 and CoO. The study of the systems

$CuSO_4 - CoSO_4 - H_2O$ and $CuSO_4 - NiSO_4 - H_2O$

has indicated that no compound formation between copper and cobalt sulphates and copper and nickel sulphates takes place.

S. M.

XXIII.—*X-ray investigation of the crystals of Hydrazobenzene and Diphenyl Nitrosoamine.* By S. G. KHUBCHANDANI.

The crystals of hydrazobenzene ($C_6H_5{\cdot}NH{\cdot}NH{\cdot}C_6H_5$) and of diphenyl nitrosoamine [$C_6H_5{\cdot}N(NO){\cdot}C_6H_5$] have been studied by the rotating crystal method using a Shearer gas tube fitted with a copper anticathode and a Bernal's Universal Photo-goniometer. The dimensions of the unit cell of the crystals of hydrazobenzene are found to be the following:

$a = 10{\cdot}46\ A^0$; $b = 10{\cdot}60\ A^0$; $c = 18{\cdot}63\ A^0$

The planes (OO1), (O1O) and (100) are halved and also (Okl) are halved when (k+1) is odd, (hO1) halved when (h+1) is odd and (hkO) halved when (h+k) is odd. The crystals belong to the space group Q_h^2 and the unit cell contains eight molecules.

The dimensions of the unit cell of the crystals of diphenyl nitrosoamine are found to be the following:

$a = 17{\cdot}08A^0$; $b = 8{\cdot}867A^0$; $c = 28{\cdot}07A^0$.

The planes (001) are quartered and (100) and (010) are halved and planes (hkl) are halved when (h+1) is odd. The crystals belong to the space group C_{2h}^8 and that the unit cell contains sixteen molecules.

It has been shown that the molecules of hydrazobenzene lie as in Fig. 1. The two rings of the molecule are inclined oppositely to the face by probably 29°. The

unit cell of diphenyl nitrosoamine behaves like an orthogonal cell and the molecules in the cell are placed as in Fig.2.

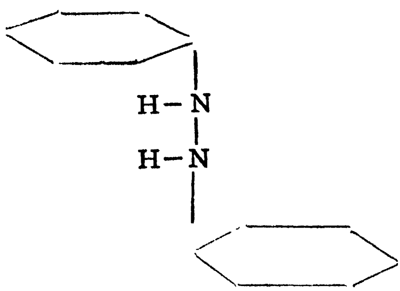


Fig. 1.

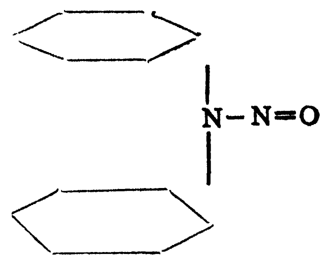


Fig. 2.

M. P.

XXV.—*Study of the constitution of the reduction products of chloral and bromal amides.* Part I. By B. H. YELBURGI.

Chloral amides were reduced with zinc dust and glacial acetic acid by Meldrum and Alimchandani (J. Indian Chem. Soc. 1925, *2*, 1 ; 1929, *6*, 253) and also by other workers in conjunction with Meldrum. They assigned the saturated formula to the reduction product

i. e.—CH OH $CHCl_3$

→—CH_2 $CHCl_2$

In the present work with chloral and bromal amides, it is found that the constitution is not as given before but of unsaturated compounds like CH : CCl_2 or—CH : CBr_2. The reduction products of chloral acetamide, chloral propionamide, chloral benzamide, and bromal benzamide are studied in detail. The following reactions are tried to confirm the constitution.

Action of dry hydrogen chloride or hydrogen bromide in dry ethereal solution did not give the compound of closed chain as was expected but a compound of the type-CHX+CHX_2 (where X is halogen) is obtained which is very easily hydrolysed to-CHOH. CHX_2.

The presence of OH group in the compound of the type CH OH CHX_2 is confirmed by the action of (1) phosphorus pentachloride (2) phosphorus pentabromide (3) acetic anhydride (4) phosphorus pentoxide (5) benzoyl chloride (6) phenyl hydrozine and (7) dimethyl sulphate.

(1) With phosphorus pentachloride the compound obtained is identical with that obtained by the action of dry hydrogen chloride on the reduction product, and it is turned into an anilino derivative.

(2) Phosphorus pentabromide gives similar products.

(3) The reaction of acetic anhydride varies with the conditions of the reaction e.g., (i) In the presence of concentrated sulphuric acid at 0° acetyl derivative is obtained, (ii) in the presence of concentrated sulphuric acid but at the temperature of boiling water,

original reduction product is obtained and (iii) in the presence of alkali at 0° an anhydro derivative is formed by the elimination of water from two molecules of the compound.

(4) Phosphorus pentoxide gives original reduction product.

(5) Benzoyl chloride in the presence of pyridine gives two products: (i) in the warm, anhydro compound is obtained, while (ii) at 0° only benzoyl derivative is obtained.

(6) Phenyl hydrazine gives diphenylhydrazones.

(7) Dimethyl sulphate gives methyl ethers.

Other reactions like that of concentrated nitric acid, ammonia, caustic soda are also tried with benzamide compound, with a view to isolate the derivative of the other half but without success ; and only derivatives of benzoic acid could be isolated.

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PART II.—*Condensation of bromal hydrate with aliphatic amides.*

The bromal derivatives are prepared from formamide to pelargon amide and their properties with the corresponding chloral derivatives are compared. It is found that in the case of bromal derivatives, higher homologues can be more easily prepared than the lower ones.

The following reactions of hydroxy group are studied.

(1) Acetic anhydride gives an acetyl derivative as well as an anhydro compound.

(2) Benzoyl chloride gives benzoyl derivatives.

(3) Dimethyl sulphate gives methyl ethers.

(4) Phosphorus pentachloride gives different products according to the quantities of the reagent used: when the condensation product and phosphorus pentachloride are in the proportion 1 : 1, OH group only is replaced by chlorine atom; with 1 : 2 a compound with two atoms of chlorine is obtained, probably due to a tautomeric change first taking place at the CO group ; while with more pentachloride the bromine atoms are replaced one by one except the last one.

Reduction of the condensation product with zinc dust and glacial acetic acid gives unsaturated compounds of the type R CO NH CH : CH Br ; but if the reduction of the acetyl derivative of the condensation product is carried out under similar conditions, the reduction products have the constitution similar to chloral drivatives i.e. R·CO NH CH : C X_2.

G. V. J.

XXVI.—*Condensation of alkyl-o-toluidines with chloral hydrate.* Part I.—By A. H. ADVANI for the M. Sc. degree in March, 1933.

Methyl and ethyl-o-toluidines are condensed with chloral hydrate in the presence of fused zinc chloride and the condensation products were isolated from the hydrochloride by means of am-

monia. They are converted into nitrosoderivatives by means of nitrous acid and their mono and di-acetyl derivatives are described. These acetylderivatives give the same reduction product p–(β–dichloroethylene.)-O-N-alkyl-aceto-toluidide-when reduced with zinc dust and glacial acetic acid. The condensation product with dilute sulphuric acid forms sulphate:

The diacetyl derivative on oxidation with potassium permanganate gives acid which on deacetylation gives p. methylamino-*m*-toluic acid which proves the point of attack for chloral hydrate.

PART II.—*Nitration of chloral alkyl-o-toluidines and chloral alkylanilines.*

By the action of concentrated nitric acid, at the temperature of freezing mixture, on p–(α–hydroxy-β-trichloroethyl) O-methyl toluidine I. a mono-nitro compound II, with the nitro group in O-position to the amino group and chloral group intact is obtained. The diacetyl derivative of II is described. If the mono or diacetyl derivatives of I are nitrated, 2–methyl-4-(α hydroxy β–trichloroethyl) phenyl N-methyl nitramine III is obtained which is acetylated.

With warm nitric acid, I gives a dinitro compound IV with the other nitro group in place of the hydrogen of the amino group. This is further acetylated. Still further action of nitric acid removes the chloral group and it is replaced by a nitro group. This nitro compound with concentrated sulphuric acid gives a dinitronitroso amine.

When compound IV is oxidised with alkaline potassiun permanganate 4 - methyl nitramino-3-methyl-5-nitro benzoic acid is obtained.

Similar compounds are obtained from p–(α hydroxy β trichloroethyl) -O-ethyl toluidine.

From p–(α–hydroxy-β-trichloroethyl) dimethyl aniline, a trinitro compound is obtained with chloral chain unaffected and a hydrogenation of the dimethyl amino group replaced by nitro group; but by further action, whole methyl group is replaced by nitro group. Their acetyl derivatives are described.

PART III.—*Halogenation of chloral-Alkyl-o-toluidines and nitration of the resulting products.*

Bromination and chlorination of chloral methyl and ethyl-o-toluidines is carried both in the presence and absence of a carrier (Iodine), when mono-halogen derivatives are obtained in both cases, with halogens in O-position to the amino group. This is proved by preparing di-acetyl derivatives and by oxidising with alkaline potassium permanganate when a bromo or chloro ketonic acid is obtained.

With nitric acid, these halogen compounds give nitroderivatives with nitro group in place of the hydrogen of the amino group as proved by the formation of only monoacetyl derivatives.

G. V. J.

XXVII.—"*Interaction of thionyl-chloride with the esters of Aromatic Hydroxy acids in the presence of finely divided copper*" (A* synthesis of thio-ethers of the aromatic hydroxy acids). By Y. M. CHAKRADEO, the Royal Institute of Science, Bombay.

Thionyl chloride is known to react with aromatic hydroxy compounds, producing chloro-derivatives, esters of sulphurous acids, Sulphoxides or Sulphones depending upon the conditions of reaction.

Phenols react vigorously with thionyl chloride to give condensation product, containing sulphur, while acids, including hydroxy benzoic acids, yield acid chlorides or anhydro compounds, wherever they react. It was, therefore, of interest to see if hydroxy benzoic acids could be made to give these compounds. Esters of hydroxy acids in question were usual since it was found in this laboratory (by N. W. H.) that various anhydro compounds are formed by the interaction of $-OH$ and $-COOH$ groups.

The mechanism of the reaction can be illustrated as follows, with the help of salicylic acid.

(i) $3\ Cu + 4\ SOCl_2 \rightarrow S_2Cl_2 + 3\ CuCl_2 + 2\ SO_2$

(ii) $2\ C_6H_4 \cdot OH \cdot COOCH_3 + S_2Cl_2 \xrightarrow{Cu} (C_6H_3\text{-}OH.COO\ CH_3)_2 : S + 2HCl + S$

(iii) $2CuCl_2 + SO_2 = Cu_2Cl_2 + SO_2Cl_2$

(iv) $3\ Cu_2Cl_2 + 4\ SOCl_2 = S_2Cl_2 + 6\ CuCl_2 + 2SO_2$

Thionyl chloride first reacts with copper to give sulphur monochloride, which in its turn, acts, in presence of Copper, on the ester to yield the condensation product. Copper chloride is formed in the first stage and sulphur precipitated during the second part of the reaction. Sulphur dioxide, which is abundantly formed in the reaction reduces cupric chloride to cuprous chloride, which is acted by thionyl chloride again to produce more of sulphur monochloride, thus rendering the reaction continuous.

Following reactions lead their support to the proposed mechanism.

(a) Anhydrous cuprous chloride in place of finely divided copper reacts to give the condensation product.

(b) Hydrated cupric chloride reacts to give the product, but anhydrous cupric chloride does not react to give the product. It reacts to give the product only when a trace of water is added or sulphur dioxide is passed in the reaction mixture.

(c) Sulphur monochloride alone does not react so as to produce the thio-ether, which is easily obtained in presence of small quantities of copper.

As regards the constitution of the condensation product (a) the presence of the-OH group in the molecule has been proved by preparing acetyl, benzoyl and methoxy derivatives; (b) The sulphur linking in p-position to the-OH group has been confirmed by denitrating the con-

densation product; (2) by brominating it first and then nitrating the bromo compound and thus getting the known bromo-nitro derivatives. When the compound is heated above 280°, hydrogen sulphide is evolved, showing the presence of the sulphide structure.

Thus the thio-ethers of salicylic acid, O-and M-cresotinic acids and 4-methoxy salicylic acid, have been prepared with their various derivatives and salts.

N. W. H.

XXVIII.—*Derivatives of salicylic acid* by M. R. Jambhekar (The Royal Institute of Science, Bombay).

The Thesis is divided into three parts:—(1) Study of the isomeric nitro-toluene-sulphonic acids (2) synthesis and constitution of 4-sulpho-salicylic acid (3) Derivatives of 4-sulpho-salicylic acid.

PART I.—Nitration of toluene p-sulphonic acid is effected so as to get the sulpho-nitro-toluene free directly, using acetic anhydride in the place of concentrated sulphuric acid as a medium for nitration.

O-nitro-toluene also has been sulphonated at various temperatures with the view to find out whether 2-Nitro-toluene–6-sulphonic acid is obtained together with the 2-nitro-toluene – 4-sulphonic acid. The work is in progress and it is expected that 2-nitro-toluene-6-sulphonic acid may be obtained from the mother-liquor on closer investigation of it.

In the meanwhile 2-nitro-toluene 6-sulphonic acid has been obtained from 2 : 4 dinitro-toluene-6-sulphonic acid by the elimination of the 4-nitro group. Composition of the 2-nitro-toluene-6-sulphonic acid is $C_7H_7O_5NS$, $2H_2O$: Barium salt $(C_7H_6O_5NS)_2$ Ba, $8H_2O$. Its sulphonyl chloride is a liquid and sulphonamide m. p. ?

2 : 4 Dinitro-toluene-6 sulphonic acid is very conveniently obtained by sulphonation first of p-nitro-toluene and subsequent nitration of 4-nitro-toluene-6-sulphonic acid. Free-sulphonic acid can be obtained direct from the nitration mixture by slight dilution. Composition: $C_7H_6O_7N_2S$, $2H_2O$; Potassium salt $C_7H_5O_7N_2SK$, $2H_2O$, sodium salt $C_7H_5O_7N_2$ SNa, calcium salt $(C_7H_5O_7N_2S)_2$ Ca, $4H_2O$, Barium salt $(C_7H_5O_7N_2S)_2$ Ba, $4H_2O$. Sulphonyl chloride $C_7H_5O_6N_2SCl$ m.p. 107°. Sulphonamide cannot be obtained. 2–Nitro–4–aminotoluene-6–sulphonic acid $C_7H_8O_5N_2S$, Potassium salt $C_7H_7O_5N_2S$, K, $2H_2O$ sulphochloride and sulphonamide: 4-diazo-6-nitro-toluene 2-sulphonate decomposes violently at 160°.

PART II.—On oxidation of 2-nitro-toluene-4-sulphonic acid with potassium permanganate at room temperature 2-nitro-4-sulphobenzoic acid $C_7H_5O_6NS$, $2\frac{1}{2}$ H_2O is obtained. Acid potassium salt is a anhydrous, barium salt $C_7H_3O_7N{\cdot}S$ Ba, $2H_2O$. Acid dichloride is liquid and diamide melts at 223°-225°: acid monochloride m. p. 202° and monoamide 192°.

On reducing the 2-nitro-4-sul-

pho-benzoic acid with tin and hydrochloric acid 4-sulpho-anthranilic acid is obtained comp—$C_7H_7O_5NS$, H_2O, barium salt $C_7H_5O_5NSBa$, 4-sulpho-authranilamide $C_7H_8O_4N_2S$ m. p. 227°-28°. The diazo sulphonate $C_6H_3{\cdot}N : N{\cdot}COOH{\cdot}SO_3$, H_2O decomposes at 163°-164°. On boiling the diazo-sulphonate with water apart from the diazo mixture free-4-sulpho-salicylic acid is directly obtained. It is hygroscopic at 35° (room temperature), comp. $C_7H_6O_6S$, $3H_2O$ (air dry: m. p. 82°); $C_7H_6O_6S$, $2H_2O$ (desiccateral: m. p. 133°); acid sodium salt $C_7H_5O_6S$ Na, $2H_2O$: Acid-potassium salt $C_7H_5O_6SK$: Barium salt $C_7H_4O_6S$ Ba, $4H_2O$: calcium salt $C_7H_4O_6S$ Ca, $6H_2O$.

On fusion with potassium hydroxide 4-sulpho-salicylic acid gives 2:4 dihydroxy benzoic acid (β-resorcylic acid) m. p. 208°.

PART III.—4-sulpho-salicylic acid is nitrated, and brominated and it has been shown that not only mono-nitro-sulpho and mono-bromo-sulpho-salicylic acid is obtained, but a dinitro-sulpho and a dibromo-sulpho-salicylic is obtained: which shows the unusual stability of 4-sulphonic acid group; unseen in 3-sulpho and 5-sulpho salicylic acids. Tribromo-4-sulpho-salicylic acid also is obtained on further bromination which shows that the directing influences of p-Br + m$-SO_3H$+O$-$Br>than the repelling influences of—OH or —COOH.

The compounds described are as follows:—

(1) $C_6H_2 \cdot \overset{2}{OH} \cdot \overset{1}{COOH} \cdot \overset{5}{NO_2}.$
$\underset{4}{}$$SO_3H{\cdot}2H_2O$, m. p. 166-167°. Potassium salt, $C_7H_4O_8NSK$, H_2O: barium salt $C_7H_3O_8NS$ Ba, H_2O: amino acid $C_7H_7O_6NS$.

(2) $C_6H{\cdot}\overset{2}{OH}{\cdot}\overset{1}{COOH}{\cdot}\overset{3}{NO_2}{\cdot}\overset{4}{SO_3}$
$\underset{5}{}$$H{\cdot}NO_2$ (decomposes above 260°).

Potassium salt $C_7H_2O_{10}N_2S$ K_2: barium salt $C_7H_2O_{10}N_2SBa$, $2H_2O$ mono-amino acid $C_7H_6O_8N_2S$: diamino acid—$C_7H_8O_6N_2S$.

(3) $C_6H_2 \cdot \overset{2}{OH} \cdot \overset{1}{COOH} \cdot \overset{5}{Br}$
$\underset{4}{}$$SO_3H$, $3H_2O$—Acid potassium salt $C_7H_4O_6S$ Br k barium salt $C_7H_3O_6$ S Br Ba, $4H_2O$.

(4) $C_6H{\cdot}\overset{2}{OH}{\cdot}\overset{1}{COOH}{\cdot}\overset{3}{Br}{\cdot}\overset{4}{SO_3}$
$\underset{5}{}$$H{\cdot}Br$, H_2O: barium salt $C_7H_2O_6$ S Br_2H_2O.

(5) $C_6 \cdot \overset{2}{OH} \cdot \overset{1}{COOH} \cdot \overset{3}{Br}{\cdot}\overset{4}{SO_3}$
$\underset{5\ 6}{}$$H \cdot Br \cdot Br \cdot 4H_2O$: barium salt C_7HO_6 SBr_3 $2H_2O$.

N.W.H.

Notes and News

We are glad to note that our " Notes and News " in the issue of last September were reviewed in the 1933 February Number of the *Nature* (No. 3303, Vol. 131) and the main idea underlying them was favourably endorsed by its editor. We pointed out then that there was a serious gap between the rapid scientific advance on the one hand and the stationary ethical position on the other—a gap which threatened the disruption of civilisation and that it was the urgent duty of every university to see that this gap was closed up, that the advance of science proceeded along a parallel advance in man's ethical and spiritual development, and that the motto of science should be not only Truth but Truth and Service.

The failure of the World Economic Conference recently held in London from which large developments were expected and on which great hopes were built is one more illustration of the statement made above. The cause of the failure of the Conference may be summed up in one word. The statesmen of the different countries of the world who met together for the first time in the history of the world for evolving a common formula to solve the present day economic world problem did not agree for the simple reason that they did not think in terms of humanity as a whole and did not wish to plan for the whole of mankind but each representative thought in terms of his own country and wanted to get as much for his country as possible. A very narrow outlook indeed! It seems that the following lesson has not yet been learnt: *viz.*, that the world is one organic whole and that the different countries of the world are so many parts of that organism and that one country cannot expect to prosper at the cost of another country, however small it may be; all rise and fall together. The weakness of one part of the human organism makes the whole organism weak. Each one should co-operate with and help the other if the whole organism is to be made sound and healthy. If the present world depression has not taught this lesson then what will? If the last great war, with all its direful after-effects, has not taught this lesson then what will? Are still greater suffering and misery and economic depression necessary to teach that lesson? Suffering is the greatest of teachers. But is there no other alternative? Cannot the same lesson be learnt in some other way

without undergoing suffering ? Yes, it is possible. *A new orientation is necessary.* In giving this new orientation the university could and should play a very important part. If it is taught from the very beginning that there is a greater pleasure and happiness in giving and sharing what one has got with others than in receiving then the knotty economic problems will automatically disappear. This brings us once again to the question with which we began *viz.*, how to bridge the great gulf between the rapid scientific and engineering advance on the one hand and the stationary ethical position on the other ? How to make man control himself before the control of Nature is put into his hands ? In other words, how to make him ethically fit to enjoy the gifts of science ? How to make him realise his great responsibility as to the use of the forces of nature placed under his command ? If he makes a good use of them then peace and joy, plenty and prosperity, leisure, culture and refinement will be the blessings he will be able to give to the whole humanity. On the other hand, if he made a bad use of them then the whole fabric of civilisation would tumble down. These dangers to our present civilisation, due to the neglect of the ethical values, have been recently emphasised by the distinguished Presidents of the British Association, Sir Alfred Ewing and General Smuts.

The excellent and thoughtful lecture given by Dr. Alexander Findlay, on " Science and the Community " on 10th November 1932 at the Textile Institute, Manchester, strikes the same note and deserves our careful study. This lecture is an attempt to show that in the study of science the utilitarian point of view has been too much emphasised at the cost of the development of the finer qualities of human nature. In the study of science we should see that the human factor and the higher values of life are not lost sight of. *Science* should now be *humanised.* The *cultural* and *spiritual* side of *science* should now be *emphasised.* Dr. Findlay wants the Scientists to recognise that Truth which is the Motto of Science is only one of the three great primary aims or ends in human nature ; the other two are Beauty and Goodness which are equally important. If we desire human nature to be developed fully and completely, if we wish to have an all round development of the human personality then all these three aims must be pursued. There is no sharp line of demarcation between Truth, Beauty and Goodness. Some branches of study emphasise one aspect and some another but each of the following subjects given in the table below should be treated in such a way that while it emphasises one aspect it should not neglect the other two :

Truth,	Beauty,	Goodness	(Mathematics, Science, Philosophy)
Truth,	Love,	Service	
Truth,	**Beauty**	Goodness	(Aesthetics, Art, Literature)
Truth,	**Love,**	Service	
Truth,	Beauty	**Goodness**	(Civics, Ethics, Humanitarianism)
Truth,	Love,	**Service**	

There is no religion higher than **Truth.**

There is no power greater than **Love.**

There is no duty nobler than **Service.**

We thus see that truth satisfies the claims of the intellect, beauty satisfies the claims of emotions and goodness satisfies the claims of what is the highest and the noblest in man (viz., Spirit) which finds expression in the *will* to be true, loving and serviceable. These three should constitute the **Religion of Humanity**. It is this religion which the University and the State should inculcate in its alumni and its people—a religion of **Truth, Beauty** and **Goodness,**—a religion of **Truth, Love** and **Service**. It should, therefore, be the main function of the University to see that it provides such facilities to its students and it should be the duty of the Government and the leaders of the people to see that they bring about such an order of society that human nature may be able to find its fullest and most complete expression through the cultivation not only of " truth " but also of " beauty " and "goodness," of love and service.

In light of what we have said above if we examine what is being done by our University to satisfy the three great primary ends in human nature we cannot help feeling intense disappointment. In our University only one aspect is emphasised *viz.*, that which satisfies the claims of the intellect and that, too, not sufficiently strongly and except for the study of literature the two other aspects are ignored altogether. It is very necessary that steps should be taken to introduce, one after another, courses of study which would make up for the existing deficiencies and help to create a new generation of men and women with an altered mental outlook who would be *true* to themselves and *loving* and *helpful* to others.

D. D. K.

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We take this opportunity of offering our congratulations to Sir Chandrasekhara Venkata Raman Kt. on his being the first Indian Director of the Indian Institute of Science, Bangalore. A Fellow of the Royal Society, England, a Nobel Laureate in Physics and a great scientist of international reputation, Sir C. V. Raman will prove to be a capable Director and being a researcher of first rank himself will infuse his spirit of research into one and all working there. Having set a noble example of sacrifice at an early age by giving up a lucrative post in the Finance Department where he would have risen to the highest grade he devoted himself to research and became a true votary of Sarasvati. A man of such high attainments and noble character is bound to inspire all the workers at the Institute, both teachers and students alike, and we have every hope that under his leadership the Indian Institute of Science will fulfil the destiny which its princely donor, the late Mr. Jamshedji Nassarwanji Tata, had contemplated for it.

* * *

Living as we do in the twentieth century—a century in which science has made such rapid progress in different directions—it becomes increasingly clear that the nation which is the first to take advantage of the applications of science, be it in matters of food and nutrition, or industry and commerce, or agriculture and medicine, or sanitation and hygiene will remain in the vanguard of civilization and its people will become the leaders of the race. Knowing this as we do we note with regret that Ahmedadad which boasts of being the Manchester of India has not got a single Central Laboratory where raw materials could be analysed and where researches on a number of problems connected with the textile industry could be carried out. There are more than 80 textile mills in Ahmedabad which buy thousands of tons of raw materials every year for their different departments which in money value come to about two crores of rupees. The address* given by Dr. T. S. Wheeler on the applications of Science in the Textile Industry shows in how many different directions science would be helpful in the mill industry.

Contrast with this sad spectacle the picture presented by Messrs. Lyons & Co. of England who are mere caterers but who were enlightened enough to recognise and appreciate the value of science in their own business. They began with one small laboratory and one chemist in 1919; within six months they found that one chemist was not enough and they added another; in 1927 they had 77 well-trained, handsomely paid chemists working either in the analytical or research section of a

*The address on "The Applications of Science in the Textile Industry" was given by Dr. T. S. Wheeler, Principal, Royal Institute of Science, Bombay on 3rd December 1932 on the occasion of the Thirteenth Annual Social Gathering of the Gujarat College Scientific Association, Ahmedabad. A copy of this address will be obtained free of charge from Prof. D. D. Kanga, Gujarat College, Ahmedabad.

big laboratory. This is an excellent illustration of the fact that the applications of science and the employment of scientists in an industry are capable of increasing the dividends in that industry and bringing prosperity to it. When will *our* industrialists realise this ?

* * *

A person cannot live without air for more than three minutes, without water for more than three days and without food for more than three months. This shows the relative importance of air, water and food. With regard to air and food attention is invited to the two articles in the present number, one on 'Smoke and its prevention' and the other on ' Dietetics: Food and Race '.

It is not an unusual sight to observe in a big industrial city like Ahmedabad every evening in cold weather more than a hundred tall chimneys belching forth smoke and polluting the atmosphere. The more polluted the atmosphere of the place by smoke and dust, the greater the number of people suffering and dying from respiratory diseases. Smoke nuisance is due to (1) factory smoke, (2) domestic smoke, (3) dust, and (4) calm still atmosphere in winter. The total quantity of coal consumed in factories and mills in a city like Ahmedabad is about 1500 tons per day. The smoke in the atmosphere indicates so much coal wasted and so much energy lost. What is the remedy ? The article on 'Smoke and its Prevention' shows the lines on which the industrialists using large quantities of coal should proceed if they wish to tackle this problem; the adoption of the measures given therein would, not only, help the industrialists to effect a great deal of saving on their fuel bills, but also help to improve the sanitation of the city by keeping the atmosphere pure and unpolluted as far as possible.

One of the measures to reduce the nuisance due to domestic smoke, particularly in the area inhabited by the labouring population which number more than a third of the whole population in a city like Ahmedabad, is suggested in the article ' Dietetics: Food and Race '. The author discusses in this article the intimate relationship between health, physical efficiency, and output of work of the working population on the one hand and the food they eat on the other. It necessarily follows therefrom that if the industrialists wish to have an increased output of work they will have to pay more and more attention to the food of their workers. Again, the preparation of a well-balanced diet presupposes a fair knowledge of the foodstuffs, which one cannot expect our labourers to possess; it would, therefore, be to the advantage of the industrialists if they provided properly constituted meals to their workers in big halls specially provided for the purpose as is being done in Japan. The meals would be prepared in about a dozen big kitchens each catering for its own class of people and using only *smokeless fuel* (soft coke). This is purely a business

proposition and we cannot too strongly impress upon the industrialists of big cities like Calcutta, Bombay, Ahmedabad, Nagpur, Cawnpore etc., of our country the need of paying their serious consideration to this important question. The example of Japan is before them. One of the reasons of the greater efficiency, and consequently the greater output of work by their workers, is the meticulous care the Japanese take in providing them with properly constituted meals under the supervision of doctors. If our industrialists properly tackle this problem they will not only benefit themselves by having an increased output of work but will also have the satisfaction of improving the sanitation of the city and the health of the people by diminishing the nuisance due to household smoke.

* * *

Millions of people in India live on a purely vegetarian diet. The researches carried out on nutrition have shown what a great influence a well-balanced diet has on the health, physical efficiency, powers of endurance, freedom from diseases, output of work etc., of those taking such a diet. They have again shown that it is necessary to have a certain proportion of animal protein and animal fat in the food of every person. Major-General Sir Robert McCarrison has calculated that to be 33% animal protein and 50% animal fat. The only food materials from which the vegetarians could expect to get these nutritious constituents are milk and milk products like curd and butter. It is therefore of the utmost importance that these should be available in a pure and unadulterated form.

The large number of raids and prosecutions that we had of late in Bombay in connection with butter and the large number of facts which have come to light in that connection show that the adulteration of food-stuffs, particularly of ghee and butter and also of milk is going on at a rate and on a scale which are simply scandalous. The existing law is not strong enough to act as a deterrent on the miscreants. It is therefore absolutely necessary that a new act should be passed which would permit of the imposition of not only a very heavy fine on those found manufacturing and (or) selling adulterated food-stuffs which are vital for the health of the people but also rigorous imprisonment.

The laws of a country reflect the progress and civilization of its people. If Mother-India wishes to have a nation of healthy, strong and virile sons and daughters, then she must see that her children get pure air to breathe, pure water to drink, pure and wholesome food to eat and clean and healthy surroundings to live in. She should, therefore, see that she has got adequate laws to punish those who pollute the atmosphere, contaminate the water and adulterate the food materials.

D. D. K.

INDIAN SCIENCE CONGRESS

In February last, representatives of various scientific and educational institutions in Poona met together and decided to invite the Indian Science Congress to hold its 21st Annual Session in Poona in January 1934, under the auspices of the University of Bombay. The university also agreed to this proposal and sanctioned a grant of Rs. 2000 towards the funds of the Local Executive Committee, who took up arrangements in connection with the Session. The Vice-Chancellor, Mr. V. N. Chandavarkar was elected Chairman of the Local Executive Committee and the Director of Public Instruction Mr. R. H. Beckett the Vice-Chairman, and representatives of the local scientific, educational and civic institutions were the members. They were assisted by two Honorary Secretaries Mr. V. V. Sohoni of Meteorological Office, Poona, and Dr. D. D. Karve of Fergusson College.

After carrying on preliminary work of organising the meeting and collecting quite a considerable amount of money, the continued prevalence of plague in an epidemic form made it necessary to change the venue of the Congress to Bombay. Major Bhatia, the Dean of the Grant Medical College and Prof. P. R. Awati of the Royal Institute of Science were appointed as additional local secretaries and they took up the work of organising the meeting with the co-operation of the old local secretaries as well as of the Staff of the Royal Institute of Science. The session was a great success from every point of view and the attendance of members from other provinces was entirely satisfactory. A handbook of information of Bombay and Poona containing contributions from a number of authorities on different aspects of educational and scientific activities was published to commemorate the occasion and will prove a valuable book of reference. The address of the President of the Congress, Prof. Megh Nad Saha, of the sectional presidents, the popular evening lectures and the social entertainments were all greatly appreciated by the delegates and the conference has been of great value in promoting scientific interest in our presidency.

D. D. K.

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THE EIGHTH CONFERENCE OF THE INDIAN MATHEMATICAL SOCIETY, JUBILEE SESSION

At the invitation of the University of Bombay, the Indian Mathematical Society held its eighth Conference in Bombay from the 21st to the 24th December 1932. It was presided over by Rao Bahadur P. V. Seshu Aiyar I. E. S. (Retired) and a member of distinguished mathematicians including Dr. Megh Nad Saha, Mr. V. Ramaswamy Iyer, the founder of the Society, Mr. M. T. Naraniengar, Principal A. V. K,

THE INDIAN MATHEMATICAL SOCIETY.

EIGHTH CONFERENCE, SILVER JUBILEE SESSION, BOMBAY.

22ND DECEMBER 1932.

TOP ROW :—Messrs. M. V. Divatia, A. D. Lawrence, B. V. Patil, S. H. Bhat, P. S. Paralkar, G. M. Fakih, S. S. Kavalekar, S. S. Ghadiali, B. R. Shah, K. R. Gunjikar, G. R. Paranjpe, D P. Patravali, C. J. Shah, A. R. Rao, J. R. Rana, L. H. Marathe.

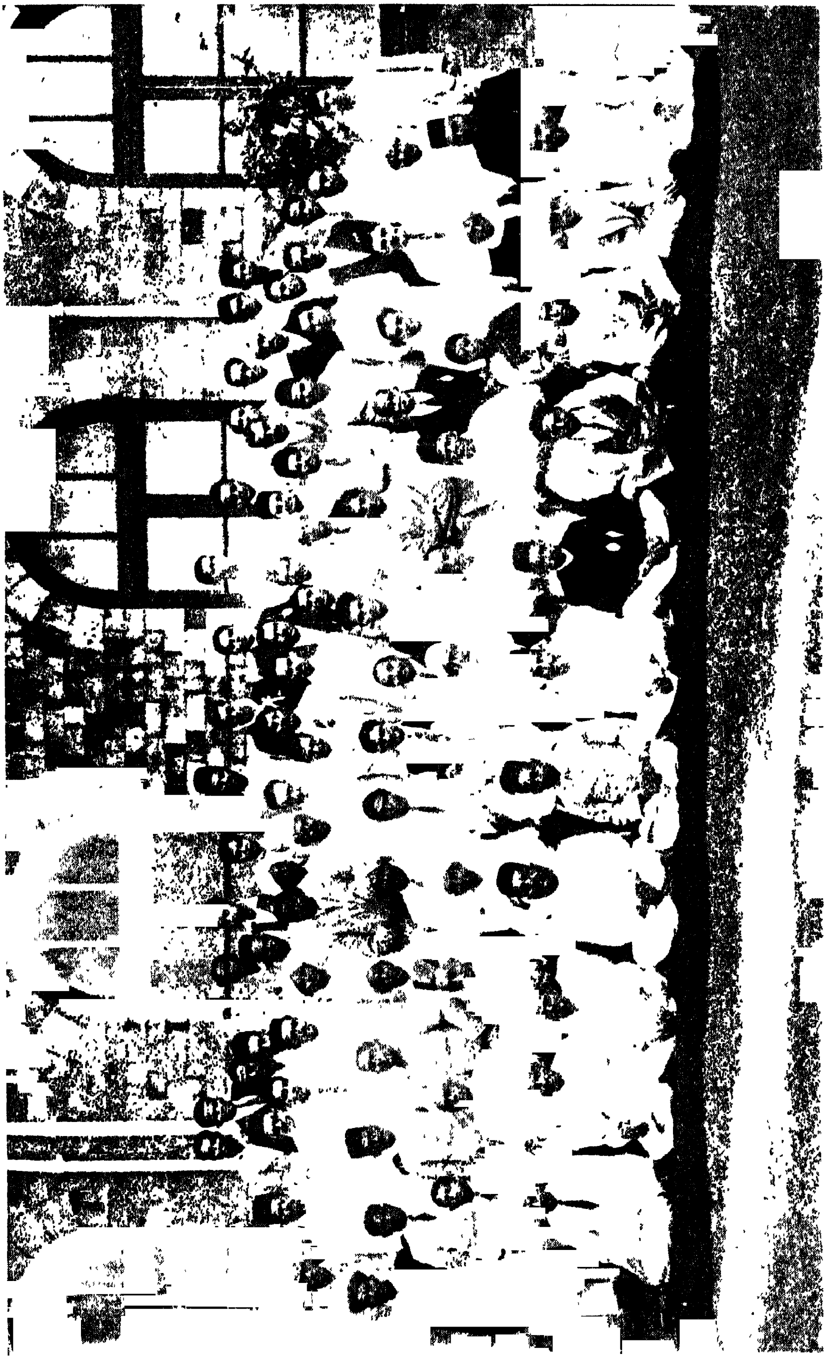
2ND ROW :—Messrs. P. V. Dandekar, N. D. Doctor, S. P. Kharas, A. L. Shaikh, V. A. Pandit, B. B. Bagi, R. Rafael, K. Nagbhushanam, G. V. Bhagvat, A. R. Sayed, K. N. Wani, C. R. Chaturvedi, P. K. Kashikar, S. R. Shaikh, M. V. Pandit.

3RD ROW :—Messrs. D. D. Vania, P. N. Sukeshwala, R. Vaidyanathswamy, L. S. Vaidyanathan, J. N. Dharap, D. M. Patel, B. S. Kalelkar, F. H. Gracias, C. N. Sriniwas Iengar, B S. Madhav Rao, S. Sastry, I. Mathai, G. S. Mahajani, K. M. Shah, G. L. Chandratreya.

BEHIND CHAIRS :—Peon, Messrs. B. K. Wagle, K. C. Shah, M. K. Kevalramani, A. K. Krishnaswamy Iengar, K. D. Panday, S. S. Pillay, D. M. Mehta, S. M. Shah, R. Siddiqui, K. S. K. Iengar, T. Buell, N. M. Shah, T. S. Wheeler, B. G. Nadkarni.

CHAIRS :—Messrs. Ram Behari, M. V. ARANACHALA SHASTRI, D. D. KAPADIA, M. T. NARANIENGAR, A. V. K. MENON, P. V. SESHU AIYAR (President), V. N. CHANDAVARKAR (Vice-Patron), V. RAMASWAMY AIYAR, Mrs. Subrahmanyam, Messrs. V. B. Naik, S. B. Belekar.

GROUND :—Messrs. D. N. Patankar, S. K. Abhyankar, P. K. Oke, S. V. Pimputkar, M. L. Chandratreya, G. R. Deo, C. A. Sheth, C. K. Koshy, K. V. Iyangar, B. S. Gai, N. H. Phadke.



Menon, Prof. Arunachala Shastri and others attended the Session. Dr. Megh Nad Saha F.R.S. gave a public address on "The Present Crisis in the Science of Dynamics". The session was also the occasion for the celebration of the Silver Jubilee of the Society.

H. E. Sir Frederick Sykes, the Governor of Bombay and the Chancellor of the University was the Patron of the Conference and gave an inspiring Inaugural Address on the morning of the 21st December. Mr. V. N. Chandavarkar, our present Vice-Chancellor then Mayor of Bombay, took a keen interest in the Conference as the Vice-Patron and he and Mrs. Chandavarkar were "At Home" to the conference on the evening of the 23rd December. Principal John McKenzie, then Vice-chancellor, was the chairman of the Reception Committee and presided at the public address by Rao Bohadur P. V. Seshu Aiyar on "The Nature of Mathematics and Religion" on the 24th December, that being also the occasion for the celebration of the Silver Jubilee of the Society.

Principal N. M. Shah, Principal G. S. Mahajani and Prof. K. R. Gunjikar were the delegates from the University of Bombay to the Conference. Prof. G. R. Paranjpe, Mr. D. C. Pavate and Prof. K. R. Gunjikar were appointed by the Board of Studies in Mathematics to be in charge of the local arrangements, Prof. Gunjikar being the Honorary Local Secretary.

An interesting programme was carried out which besides the reading and discussion of papers included three public addresses (in addition to those by Dr. Saha and Rao Bahadur Seshu Aiyar, one by Dr. R. Vaidyanath Swamy on the "Nature of the Continuum"), two "At Homes", (one with Mr. and Mrs. Chandavarkar and the other with the Reception Committee), Jubilee Celebration and presentation of an address to Mr. M. T. Naraniengar (a visit to the Oriental Life Assurance Company's offices) and a trip to Elephanta. The public functions were arranged at the Sir C. J. Public Hall, while the rest of the programme took place at the Royal Institute of Science at the kind invitation of the Principal Dr. T. S. Wheeler. As a special feature of this Conference, were the two Discussions on the teaching of Mathematics in schools and in the University which were well-attended and greatly appreciated.

The Conference ended with a trip to Elephanta on the 24th December. The expenses were met from the generous grant of Rs. 1000/- made by the University of Bombay, for which thanks are due from all interested in the progress of Mathematics in this Presidency. It is to be hoped that the enthusiasm created by the visit of the Society to Bombay will be kept alive by the foundation of a School of Mathe-

matics under the auspices of the University. The public of Bombay led by the Mayor also showed a keen appreciation of the work of the Conference by contributing handsomely to the reception of the Delegates and attending the public functions in large numbers. The Conference passed sincere votes of thanks to them all.

K. R. G.

THE LATE REV. F. J. SACASA, S. J.

Obituary

The Late Rev. F. Sacasa, S. J.

On July 1, last—shortly after the re-opening of the College, one of the Bombay Colleges, St. Xavier's College, lost its Principal, the late Rev. F. Sacasa S. J., who died at the early age of 44.

Fr. Sacasa had been Principal of the College for a little more than a year only, but he had already won the esteem of staff and students alike by his genial manner, his constant cheerfulness and his sympathetic treatment of all alike. A large educational institution offers new and often intricate problems day by day, and the man who is called upon to solve these, has a difficult task set before him. Fr. Sacasa entered upon his work with a spirit of great optimism and after winning the sympathies of all those with whom and for whom he had to work, his task became a fairly easy one, even though at times the large amount of routine work, taxed his physical strength to its utmost. He was perhaps too anxious to do well, and the heavy work at the beginning of the new academic year told on his health.

To make matters worse, Fr. Sacasa had for some time been suffering from slight chronic appendicitis, which now became acute and an operation became necessary. In spite of his own, the Doctors' and his friends' confident hopes, the patient was not able to stand the strain of the operation and he died a few days later.

The funeral which was largely attended by students as well as by many of his colleagues, of other Colleges, showed how popular the deceased was. The University was represented at the funeral, by the Vice-Chancellor himself and the Registrar. The death of one of its most able professors is a great loss to St. Xavier's College. All the Bombay Colleges held condolence meetings, or closed for one day in token of respect for the memory of the deceased.

Fr. Sacasa was born at Barcelona, Spain, on June 7, 1889. After his early education in his own native town, he joined the Jesuit Order at the age of 16, and went through the ordinary course of a Jesuit's education—in his case no less than 13 full years of classical, philosophical and theological studies, to which were added special studies of science and especially chemistry, which he was ultimately to make his special branch. He spent a number of these years in America, mostly at the University of St. Louis, Missouri. After completing his studies of philosophy, he was sent to teach chemistry for a number of years, at

the Ateneo, the Jesuit School of Manila, in the Philippine Islands, after which he returned to the United States, where he specialized in chemistry before he came out to Bombay to take up the post of Professor of Chemistry at St. Xavier's College. This he held from 1924 till the end of his life, adding to it the work of Principal during the last year.

Fr. Sacasa was a man of rare talents, of quick perception, and capable of getting through a large amount of work in a short time. His scholastic career had been brilliant, and as a teacher he was able to hold the attention of his hearers and to make the teaching of a very dry subject, both lucid and interesting. He was, of course, frequently an Examiner in Chemistry, and at the time of his death he was a member of the Senate, of the Academic Council and of the Syndicate of the Bombay University.

G. P.

Reviews

Contribution à l'analyse des substances toxiques et des stupéfiants. Sur la découverte de la non-spécificité des réactions chimiques employées pour déceler la présence du chanvre indien ou hachich et dérivés. Par Henri Trollé, Ingénieur-chimiste diplômé de l'école d'ingénieurs de Lausanne, expert francais près le tribunal mixte du Caire. Le Caire—Imprimerie Paul Barbey. 1933.

This short pamphlet of 21 pages contains two parts :—

1. In the first part the author describes chemical experiments which prove that (i) Beam's reaction may fail to detect the presence of cannabinol in an extract which contains it; (ii) this same reaction obtains with other drugs than Indian Hemp and is not, therefore, specific; (iii) there is no specific reaction for cannabinol.

2. The second part is a reprint of Dr. Giuseppe Rende's contribution to *Officina* No. 6, November-December 1931, in which he proves by chemical and physiological experiments that Beam's reaction is not specific for Indian Hemp.

J. F. C.

Through Wonderlands Of The Universe. By R. K. GOLIKERE. Pp. XVIII+400 with Frontispiece. Taraporevala Sons and Co., Hornby Road, Bombay. Price Rs. 6-4-0.

This book deals with a variety of subjects of geological, physical, astronomical and astrophysical nature and in the words of the author "it is not a learned treatise, but a simple elementary study, a modest attempt to awaken a taste for Science among those who ordinarily take little interest in it".

The first chapter contains information about the nature of the earth and a collection of some interesting finds in its interior observed in different parts of the world. The chapter ends with remarks on some theories about the physical state of the earth's interior, causes and nature of earthquakes and their probable depth. In the next chapter is given some interesting information about the ocean, with a brief account of marine zoology. The third chapter contains information about some well-known low-lying lands, mountains, lakes, springs, waterfalls, heights of some clouds, structures built in various parts of

the world, the highest heights reached by balloons, birds, men etc. It also incidentally describes the nature of work done at various offices of the India Meteorological Department. The next two chapters give information about volcanoes and detailed accounts of some well known volcanic eruptions and the giant peaks of Asia.

Chapters VI, VII, VIII and IX deal with the troposphere, the tropopause, the stratosphere and still higher regions of the earth's atmosphere. These chapters contain information about phenomena observed at various heights in different parts of the world. A short account of researches of various investigators, of some natural phenomena and of the composition of the atmosphere is also given in these chapters. About these chapters it should be stated that the author could have given a more connected account of the various causes which are responsible for the weather experienced over different parts of the world and thus create an interest about a subject which concerns everybody from the point of view of the prosperity of the country—especially of a country like India whose major part of the population lives on Agriculture.

In chapters X to XVII the author has treated the subject of solar system, the galactic system and of the physical condition of stars and the nebulæ. Probably the subject being too wide the author could not give much attention to various details about celestial bodies which one would have liked so much.

The author describes some giant telescopes of the earth in chapter XVIII. The next three chapters are short and deal with "Outer Space", "the Roof of the Universe" and the views of Sir Arthur Eddington on "Space and the Universe". Chapter XXII gives some idea about the weight of the Universe.

The last two chapters give a brief account of Astronomy in Asia up to the 18th Century and Hindu Cosmogony and Cosmography.

In this book the author has dealt with a variety of subjects and as such it is but quite natural that too much detail about various things could not be given. The author has been very careful in his selection of things to be presented to the reader in order to make the book popular, and as far as possible, has taken note of some of the latest relevant investigations. The book is sure to awaken a taste for Science amongst laymen—this has been the aim of the author in writing this book—and the author should be congratulated on it.

B. N. D.

The Physical Nature of the Universe.—By J. W. N. SULLIVAN. Victor Gollancz Ltd. pp. 143, price 1*s.* 6*d.*

It is no easy task to describe within the compass of a little more than one hundred pages the modern revolution in physical thought, but the author of this book (Outline series) has done it in an admirable manner. He begins with Galileo who is considered to be the first man to make the idea of motion precise and amenable to exact mathematical treatment. Then he gives a brief account of the dynamical theory of heat and the kinetic theory of matter. In a short chapter that follows he clearly describes the various vicissitudes through which the atom has passed, shows how the hard and unbreakable atom of old had to make room for the Rutherford-Bohr atom having an exceedingly complex structure and how even this recent model has been finally abandoned so that at present the atom has passed out of all recognition and remains merely a mathematical symbol. Then he takes up the question of the ether and shows how the conflict between the results of experiments designed to investigate its properties brought us to the restricted theory of Relativity and describes some of the important results of this theory. Next he turns to the problem of gravitation and shows how Einstein's General theory of Retativity which attributes gravitation to the curvature of space is more logical and satisfying than the old Newtonian conception. Lastly he shows how all the known laws of physics are macroscopic and therefore statistical and how Heisenberg's Principle of Indeterminacy makes exact measurement of the properties of individual atoms impossible and thus strikes at the root of the doctrine of scientific Determinism. Broadly speaking modern physics tends to think of the universe as much more subjective than the old and the methods of science cannot tell us anything about the ultimate stuff of which the world is made, at the most they give us some idea of its structure.

The book is written in a simple and nontechnical language and can easily be followed by those who have a desire to get a glimpse of the trend of modern physical thought but have neither the leisure nor the equipment to read the more ponderous treatises on the subject.

S. N. D.

Practical Chemistry.—By N. M. SHAH, M. Sc., Second Edition (Dharwar : The Students' Own Book Depot, 1933).

In this handbook the author has made a successful attempt to meet with the requirements of the syllabus of the Intermediate Science course in Practical Chemistry of the University of Bombay,

Part I deals with the methods of preparation and purification, a study of the properties of simple and compound substances, determination of equivalent and molecular weights and exercises in gravimetric and volumetric analysis commonly recommended in elementary practice.

Part II gives an account of the customary dry and wet reactions of positive and negative radicals and of the systematic procedure to be followed in the qualitative analysis of a single substance.

Special attention has been paid to emphasise the fundamental principles of theoretical chemistry and to show how a neat entry of the experimental results and calculations obtained therefrom can be made in the journal.

The book is expected to be of great use to students as well as instructors of the Intermediate Science Chemistry Classes.

M. S. S.

The Fourier Integral and Certain of its Applications. By Dr. N. WIENER, 1933. (Cambridge University Press)

The subject of Fourier series has been fairly exhaustively treated in a number of standard treatises on Theory of Functions and in special books on the subject. The same has not been the case with the Fourier integral and one is compelled to refer to various journals for results which would have otherwise found a natural place in a modern work on the subject. Dr. Wiener's book is in no sense a systematic treatise on the subject nor was it written from that point of view. It is an elaboration of a course of lectures delivered at Cambridge and hence in a sense, as the author himself says in the preface, the treatment is fragmentaiy. We welcome the book, however, as it makes available in a book form most important recent researches on the subject from the pen of an author who has himself contributed so much to the development of the subject.

For generality of results Lebesgue's theory of integration is indispensable, and in the introductory chapter the author gives a résumé of that theory as well as a short discussion of developments in orthogonal functions.

The modern theory of Fourier integral starts with Plancherel's theorem, that if

$$f(x) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{+\infty} g(u)\, e^{iux}\, du, \quad g(u) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{+\infty} f(x)\, e^{-iux}\, dx,$$

and if $| f(x) |^2$ is integrable (L), then $| g(x) |^2$ is also integrable (L). Chapter I deals with Hermite's polynomial and Hermite's functions and the above theorem is established with their help. Chapter II deals with the General Tauberian Theorem. It is not apparent how a Tauberian theorem, which is statement of conditions under which we can pass from one limit relation to another, could have any connection with Fourier integrals. Dr. Wiener establishes a very general theorem by means of Fourier integrals and deduces a great variety of Tauberian theorems in chapter III. Two important applications, treated in this chapter, are to the Prime Number theorem and the theorem on the 'mean-square' modulus of a function.

The last chapter is on generalised harmonic analysis and almost periodic functions. The latter subject has been treated at length in the work of Besicovitch published last year. Bohr's fundamental theorem that an almost periodic function can be represented by a generalised Fourier series is proved here by a comparatively simple method.

The work is an important and welcome addition to mathematical literature and we may express a hope that the author may find time to give us an exhaustive and systematic treatise on the subject in the near future.

N. M. S.

Mass Spectra and Isotopes. F. W. ASTON, SC. D., F. I. C., F. R. S., Arnold and Co., 1933.

This volume deals with a subject which the author has made peculiarly his own. It incorporates the substance of lectures delivered at the University College of Wales, Aberystwyth, on the Aberystwyth Lecture Foundation during the Session 1931-1932. Part I is historical, Part II is mainly experimental and deals with the Production and Analysis of Mass-Spectra, Part III gives an account of each individual element relative to its isotopic constitution developing the new science of "nuclear" chemistry. The rapid progress in the artificial transmutation of elements is bound to render increasingly valuable this collection of data. Part IV is theoretical and discusses the implications of the results which have been obtained by the use of the mass-spectograph.

It was in 1912 that the application of the method of positive ray analysis to neon indicated the existence of isotopy among the non-radioactive elements. With the completion of the mass-spectograph in 1919 the non-homogeneity of neon was confirmed and a few weeks later the isotopic complexity of chlorine and mercury was demonstrated, and the whole number rule formulated. Progress since then has been continuous

until in 1932 the hydrogen isotope of mass 2 was discovered, and at present, out of all the elements known to exist in reasonable quantities, only eighteen remain without analysis. Of these eleven are rare earth elements.

The discovery of the heavy isotope of hydrogen is of particular interest. It has recently been found that heavy water from the heavier isotopes of hydrogen and oxygen can be concentrated by electrolysis, and in the Journal of the American Chemical Society for October, 1933, some of the properties of this water have been listed. Its density is over 1·1 and its viscosity some 40% greater than that of ordinary water. Heavy water appears to be toxic to fresh water organisms.

This fascinating book on a new and fundamental branch of Chemistry by one who is responsible for practically all the developments of the subject discussed is certain to become a classic. It is written in a clear and simple style and can be recommended alike to the student, the general chemist and the isotope specialist.

T. S. W.

Introduction to Thermodynamics for Chemists. D. JOHNSTON MARTIN, B. Sc., Ph. D., Arnold and Co., 1933.

This book is a complete introduction to modern thermodynamics for chemical students. Besides dealing with the fundamentals of the subject, it includes chapters on Lewis' " Activity " method of treatment of solutions on the modern theory of strong electrolytes, and on the Third Law of Thermodynamics. The treatment is up-to-date and references to the original literature are given. In some instances statements made in the literature have been accepted in an uncritical manner but a book covering so wide a field must naturally be more of a compilation rather than a critical monograph.

Thermodynamics is probably the most difficult subject a chemical student has to study ; in no subject is he more dependent on the skill of his teacher in imparting accurate and fundamental knowledge. The student must always be clear as to the quantities under discussion, their signs, and the conditions under which the alterations in these quantities occur. The interests of the average physical chemist are not, however, in the more mathematical portions of his subject, with the result that too often, the subject is badly taught due to vagueness on the part of the teacher as to what he is really teaching. In desperation the student crams for his examination and disgorges lumps of mentally undigested matter on the examiner in answer to book-work questions leaving

numerical examples and the development of book-work severely alone. Once the examination is passed, thermodynamics is forgotten.

This book, therefore, will be useful to the teacher rather than the student. For the beginner its utility could be improved by the introduction of general questions and numerical examples at the end of each chapter, and by the provision of a table of symbols at the beginning. It would be of advantage also if some of the industrial applications of Thermodynamics had been considered.

T. S. W.

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Journal

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POETRY AS A CRITICISM OF LIFE

This dictum, which is first put forward in the *Essays in Criticism* (1865) remained for Arnold, throughout his life, the main tenet of his critical doctrine. It appeared first in the wider form, "all literature is a criticism of life." Later, he concentrates more particularly on its application to Poetry, and it then takes the form "poetry is a criticism of life", with the qualifying words added that such criticism, in the case of poetry, "has to be made conformably to the laws of poetic truth and poetic beauty."

Prof. Saintsbury, in his *History of Criticism* (Vol. III, pp. 5312) makes short work of the famous definition. What does "criticism" mean here? he asks. "Either the word is employed in some private jargon, or it has no business here." Arnold's own explanation that "criticism means the application of ideas to life" seems, says Saintsbury, to show that he is using the word to some private sense; but it does not really help us. To say that literature is the application of ideas to life is a truism. To say that poetry is the application of ideas to life, "under the conditions fixed for poetry", is a mere repetition of the truism, and adds nothing to our conception either of literature or of poetry. Saintsbury concludes that Arnold's dictum really conceals the doctrine of the *Poetic Subject,* as against that of the *Poetic-Moment,* and dismisses it summarily and with a kind of impatient contempt.

Such treatment of the dictum, however, is hardly fair. The definition, after all, is Arnold's, and the only fair way of

dealing with it is to hear what Arnold has to say about it. And there is no lack of explanatory comment in Arnold, which, while it never perhaps quite does away with the indefiniteness surrounding the word "criticism", nevertheless tells us a good deal about what was at the back of Arnold's mind in making it. The three best sources, to which to refer for such comments, are the essays on *Wordsworth* and *Browning* and the introduction to Ward's Edition of *The English Poets.*

The essay on *Wordsworth* gives us most clearly what Arnold means by "ideas". Quite plainly, he tells us there, he means "moral ideas". But, lest we should interpret this word too narrowly, he adds that "a large sense is of course to be given to the word moral." Let us, he says, "meditate upon that real inexhaustible word 'life'" and our conception of "moral" will then be that of anything which contributes wisely and profoundly to the understanding and the living of life. Wordsworth, for example, is a great poet because "he deals with that in which life really consists." He is intent upon "the best and master thing." And, if we ask what this best and master thing is, in Wordsworth's case, Arnold tells us that the answer is "quite simple": "Wordsworth's poetry is great because of the extraordinary power with which Wordsworth feels the joy offered to us in Nature, the joy offered to us in the simple primary affections and duties, and because of the extraordinary power with which, in case after case, he shows us this joy, and renders it so as to make us share it."

The application of ideas to life is, thus, in Wordsworth's case, the application of a central, sovereign idea—the idea of a deep, inner joy of living. And this is a *moral* idea, because, once grasped and shared, it enables us to live in a different way, more nobly, more understandingly. There may be other ideas, equally central and sovereign, in other great poets; but each of them will have this essential mark, *i. e.* that it will possess a transforming and ennobling power; and in this sense all of them will be "moral".

Now this example drawn from Wordsworth enables us at once to make two critical comments on Arnold's theory. One is that what the word "ideas" means here is not a number of separate ideas, but the *essence* of a poet's philosophy—(*i. e.*, the one deepest idea which pervades all his thinking about life and lies, so to speak, at the heart of all his criticism of it—in other words, the key-note of his whole attitude). The other is that the word "application" is too external. What the great poet does is, not to apply ideas to life, in the sense of laying something against it

from the outside, but to *elicit* or draw forth, from life, something which is already there, and which his genius enables him to detect. And he is able to detect it, because there is something in his genius which is akin to it. It is, thus, just because Wordsworth is attuned to the deep, spiritual joy of life—that he has it within him—that he is able to find it in Nature and in the simple affections and duties which link humanity together. The poet's spirit is, in this way, a spirit which, in its own being, shares something of the larger life of Nature and which, in proportion to the degree of its sharing, is able to elicit from Nature and from life something of their inner secret. Such a secret, of whatever kind it be, has, when disengaged and made manifest, a "moral" quality, since it illumines and transforms life and thus reveals a way of nobler and wiser living. The greatest poet is he who can, in this way, reveal most; which is only another way of saying that the greatest poet is the man who shares most fully, in his own being, in the larger spiritual life of Nature, and who thus possesses the key within himself, wherewith to unlock her secrets.

If we interpret Arnold's theory in this wider way by getting rid of the conception of separate ideas, as well as of the externalism of the word "application," then all the rest of what Arnold has to say about great poetry follows naturally.

Thus:—

Arnold insists over and over again on *Sincerity*. Where sincerity is absent, he says, "we have not the man speaking with his real voice." Hence what we get is "something poetically unsound." Why is this? It is because the insincere writer is trying to get out of Nature something which he has not already in himself. He is trying to open a door without the necessary key. The true poet, on the other hand, speaks "from the inmost soul." In other words he is eliciting from life and Nature simply that which exists, as a central idea, or attitude, or illumination, at the heart of his own being.

Similarly, over and over again, Arnold insists on what he calls a "*high seriousness*" as the mark of the greatest poets, and as perhaps the chief thing which is lacking in poets of the second rank. His judgments as to which particular poets possess it and which do not, may be at times capricious (*e. g.*, his denial of it to Chaucer), but his general position is clear. "High seriousness" is that nobility of tone which is possessed by all the world's poets who share, in an eminent degree, in the larger, deeper life of Nature. It is not something that can be assumed or cultivated. It is the natural dignity that comes from greatness. It is like the natural

majesty of a great King; and in the realm of expression it shows itself in the possession of what Arnold calls the "grand style". Critics have carped at Arnold for furnishing us with no precise definitions of these terms. But it is just because they denote an impalpable quality, exuding (as it were) from an inner greatness, and exuding naturally and spontaneously just because of that inner greatness, that they cannot be defined. They are as spontaneous and natural as the way in which a man carries himself, or the tone of his voice. And because they are natural, they are, in the greatest poets, continuous and persistent: and this furnished Arnold with one of his tests. The smaller poet may hit the grand style, or a note of high seriousness, for a fleeting moment. In the greatest poets these are always present; for they are part and parcel of the man. The poet who has the seal of royalty on his brow cannot help being royal.

Then again the application of ideas to life must be, according to Arnold, a poetic application—one in conformity with the "laws of poetic beauty and poetic truth". What does this mean? Let us try to get at the meaning by mentioning two things, referred to by Arnold, which it does not mean.

It does not mean a definite system of thought. Wordsworthians, for example, have often taken pride in proclaiming that Wordsworth's moral ideas are as clear and self-consistent and as capable of being reduced to a system as are those of Bishop Butler. Arnold has no difficulty in showing, by quotation, that Wordsworth is always least poetical where he is most systematic. To speak of Wordsworth's "philosophy" is to single out the unreal and illusory part of him. The real thing is his poetry. Arnold suggests that this is a universal truth. "Perhaps," he says, "we shall one day learn to make this proposition general" and to say: "Poetry is the reality, philosophy the illusion." So that "ideas" for Arnold, in his formula of the "application of ideas to life," does not mean a *system of ideas*. For, in so far as such ideas are presented as a system they cease to be poetical.

Nor again does it mean an application of ideas to life, in which such application is governed by an "almost exclusive attention to the qualities of regularity, uniformity, precision, balance." These, says Arnold, are the qualities of prose, not of poetry; and it is for this reason that he denies to Dryden and Pope the name of poets, in the strictest sense of the term. The verse of both is often admirable; but it is verse, the special mission of which is to inaugurate an age of prose and reason. What is it then, which it lacks, and which is necessary to the highest poetry? Arnold answers: "high

seriousness and (even putting that aside) poetic largeness, freedom, insight, benignity."

Now, if we examine this last list of qualities, we shall see that they are all of them incapable of strict definition. We can feel what they mean; we cannot state it. And yet they are the terms which Arnold employs to denote what he means by the *poetic* application of ideas to life. Such application must have high seriousness, poetic largeness, freedom, insight, benignity. The unsympathetic critic may well become impatient here. Why this playing with vague and indefinable terms? The sympathetic critic, on the other hand, will understand the reason. It is that Arnold is thinking of an atmosphere, an inner quality, which greatness, as it were, breathes forth and which is immediately recognisable by those who have the power to judge. All the terms used merely represent that felt largeness of spirit, which comes when a poet shares greatly in the larger life of Nature. Such largeness is felt first as beauty; only afterwards, when our intellects have had time to play upon what it tells us, do we recognise it as truth. In Nature, truth and beauty are one. In poetry, the poet's prime task is to elicit the beauty; and when this is revealed, we look again and find that it is truth. The poet's "criticism of life" is thus the magical revelation of beauty, made possible by the participation of the poet, in his inmost being, with the secret beauty of life and Nature. And it is just because the primary revelation, effected by him, is one of beauty, that all terms used to describe the revelation become indefinable—for beauty is itself incapable of definition. Had the primary revelation been one of truth, considered as separate from beauty, the case would have been different. But then the thing would not have been poetry; for what distinguishes poetry from prose is, in one of its aspects, just this—namely, that whereas prose, dealing with what in Nature is the amalgam of truth and beauty, concentrates on the truth aspect, the beauty aspect being incidental only, poetry, on the other hand, concentrates on the beauty aspect, and the truth follows as a matter of course. Thus, when Wordsworth reveals the deep joy of living, he reveals it first as a beauty: the intellect, working upon it as thus presented, finds it to be also a truth.

All the qualities, therefore, which are mentioned by Arnold as necessary to *poetic* presentation, are qualities necessary to the presentation of beauty; and they become the more conspicuous according to the depth to which the poets bring shares in the beauty of Nature. Where that participation is profound and continuous, as in the case of the greatest poets, then such qualities as high seriousness, sincerity, largeness, freedom, etc., follow naturally. For

these are part of the very atmosphere in which such a poet moves. They are qualities of Nature shared by the poet in the degree in which he participates in Nature's life.

Arnold's difficulties as a critic may be summed up in a single sentence. A Greek by temperament, trained in the Greek tradition, he endeavours to apply to poetry the old objective Greek canons of criticism, using external terms to express what it is that he demands of great poetry, whereas what he really demands of great poetry is something internal. It is a quality, or essence, in the poet's nature. Thus when he speaks of a "Criticism of Life," what he really means is a vital union between the soul of the poet and the soul of Nature, enabling the poet to deal with Nature in a living, and hence a true and inspiring way. When he speaks of the "application of ideas to life," he means something altogether more inward and profound than what the words convey; i.e., an eliciting from life of those elements of beauty and truth which are already within himself and which, consequently, he is able to draw forth from it. When, finally he speaks of "high seriousness" and the "grand style," he means really that tone of mind and tone of utterance which are the inevitable concomitants of this deep union with the greater life of Nature.

Arnold's whole emphasis, in a word, is on the man. It is this perhaps which makes him over-value Byron—since, in Byron, it is the man himself who astonishes. It is this also, which, over and again, when definition is obviously impossible, induces him to show to us the actual poet, in the form of quotations. "You do not understand what I mean in the abstract," he seems to say—"Well, never mind abstractions. Just listen to this passage, or that, and you will feel what I mean." And he then gives us a string of passages to illustrate what he means by the "grand style," or "high seriousness" or "the poetic application of ideas to life."

The secret is that all that Arnold tries to do by precept and external generalisation, has really to be done by feeling. We cannot define greatness; we have to feel it. The modern, poetic Arnold realises this; the cultured Arnold, bred in the Greek tradition, will not let him say so definitely. And out of this clash of two personalities practically the whole difficulty of Arnold's literary criticism arises.

E. A. WODEHOUSE

CHAUCER'S TROILUS AND CRISEYDE*

1.

Chaucer's *Troilus and Criseyde* takes rank among the half dozen great really long, single, non-dramatic poems in the English language—along with, let me say, *The Faerie Queene, Paradise Lost, The Prelude, The Ring and the Book,* and *The Testament of Beauty.* I leave the sixth (if indeed there be one) to the reader's choice. And it is perhaps the most generally interesting of all these : it is at once the earliest and nearly the most modern ; reflecting the middle ages, heralding the renaissance, and anticipating the modern novel, by reason of its concern with motive and mental adjustment rather than with the relation of physical adventures.

In thus facing both ways, towards the past and towards the future, *Troilus and Criseyde* is characteristic of Chaucer, and Chaucer here, in particular, surpasses the mere Gowers of his age. *The Canterbury Tales* display the same quality; the Knight is mediaeval; the Wife of Bath would hardly be out of place in twentieth century America. But the *Canterbury Tales* is made up of varied material and is not one poem in so plain and clear a sense as *Troilus and Criseyde.* I regard *Troilus and Criseyde* as Chaucer's greatest single creation.

2.

Troilus and Criseyde is not easy to date precisely. But we may safely say that it was written pretty continuously (as the *Canterbury Tales* was not) at a time when Chaucer was at the zenith of his skill. He was probably born in the early forties of the fourteenth century. *Troilus and Criseyde* was written in the early eighties. He was then in the prime of his life and of ripe experience. All his days he had been in the King's service, in war and peace, in England, in France and recently on two missions to Italy. In his youth he had written much in the conventional French mode, introducing French culture to his countrymen and perfecting the poetic use of the English tongue. Just before writing *Troilus and Criseyde,* he had composed a long poem in the same 7-lined stanza—*The Parlement of Foules,* and had translated that favourite religious classic

* This paper is an adaptation of portions of one of a series of lectures on Chaucer delivered in Bombay, and in Poona, in connection with the Wilson Philological Lectureship, 1932-33.

of the middle ages, *Boethius de Consolatione Philosophiae.* About the same time he wrote the *Hous of Fame.* In both these poems (not, of course, in the prose translation) we see a touch of Chaucer's later mood, the note of pure comedy that is otherwise so rare in mediaeval literature, where the artist was either conventional or seriously rebellious against convention. Read the debate between the birds in the *Parlement of Foules,* or Chaucer's dialogue with the Eagle, or Jupiter's comments on the poet in the *Hous of Fame.* Realism combined with the dry, critical humour of comedy, are here seen for the first time in our literature. But the framework of the *Hous of Fame* could not give Chaucer a fair field for his gifts or his temperament, and he was already working on what he saw to be a better vehicle for their expression.

It is surprising that after completing such a ripe and masterly work he should have returned to the conventional structure and rather academic tales of *The Legend of Good Women,* for in style *Troilus and Criseyde* is the maturest of Chaucer's poems, except for the general plan and the later portions of the Canterbury Tales. It was probably begun very soon after his return in 1378 from Italy, where he had become acquainted with Boccaccio's *Filostrato,* and he worked on it for several years, perhaps letting the books be read separately as they were completed and copied by the scrivener.[1] The other three poems of this period would therefore not attract the whole of his attention and they were taken up, partly as interludes in the writing of the greater poem and partly to celebrate some particular occasion or by command. Two of the three are incomplete. Probably when *Troilus and Criseyde* was finished, Chaucer felt free to move on to another piece more important than these, and more in harmony with his developed ways of thought, and took up in earnest the composition of the Canterbury Tales.

3.

This view of the composition of *Troilus and Criseyde* is borne out by the progressive advance in poetic skill displayed in the five books. The last two are noticeably better written than the first three, not in mere technical skill but in depth of character and subtlety of motive. In particular, as Courthope has pointed out, it is in these last books that Chaucer decisively moves from his mediaeval to his modern phase.

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1. Hence the association with the earlier completed " Boece " in the Words unto Adam Scriveyn. In my lectures I gave detailed reasons for rejecting Skeat's Evidence in favour of a comparatively early date for the completion of *Troilus and Criseyde.*

"The poetical structure which Chaucer built on these Boccaccio's foundations is a fine example of the character of his genius, at once flexible and inventive. *Troilus and Criseyde* reveals the influence on his mind of all the great intellectual forces of the period: Catholicism, Feudalism, Democracy and the Renaissance. The interest of the poem is concentrated in the development of the character of Cressida. In the first three Books Cressida's conduct is regulated in strict conformity with the standing rules of chivalrous society. She resists her own inclinations, and withstands the solicitations of Pandarus on behalf of Troilus, with all the oppositions of argument required by the science of the Troubadours and the regulations of the Courts of Love. André le Chapelain himself could have found no fault with her behaviour. When she finally surrenders to Troilus she has as yet been guilty of no offence according to the moral code of the time, which merely required her to be true and steadfast in her attachment to one preferred lover. Of all this refined casuistry and analysis there is no trace whatever in the Cressida of Boccaccio, who represents his heroine simply as a young widow in love. At the same time, while preserving the chivalrous standard, Chaucer with extraordinary skill, by associating Cressida with the semi-comic character of Pandarus, who plays the same part in his story, as afterwards in Shakespeare's play, removed the heroine's character from the metaphysical region of chivalrous love, and reduced it to a human and almost bourgeois level. It is not till the fourth book that the deterioration of Cressida's nature reveals itself incidentally in the facility with which she listens, without displeasure though without response, to the artful love-making of Diomede..................(Courthope, *History of English Poetry*, Vol. I, page 262 seqq.)

Every writer who has dealt with this poem has, from his own point of view, borne witness to this same phenomenon, the grafting by Chaucer of a fresh shoot upon the stock of mediaeval literature. Wm. Rossetti, who made a close comparison of *Troilus and Criseyde* with its chief source, *Filostrato*, wrote of it as—

> "peculiarly memorable and unfailingly fascinating, as combining in itself at once the very topmost blossom and crown of the chivalric passion and gallantry, and the exquisite first-prints of that humorous study of character in which our national writers have so specially excelled." (Comparison between Boccaccio's *Filostrato* and Chaucer's *Troilus and Criseyde*: Introduction (E. E. T. S.)

And W. P. Ker, than whom none was ever more intimately acquainted with the various strains in mediaeval literature, wrote to

the same effect in a passage (In *Epic and Romance*, pp. 369-70), too long to quote here but worth reading in full by all students of the poem.

4

I have not space here for a detailed study of Chaucer's sources. These are well known. Neither Homer, nor even Quintus Smyrnaeus were among them. The pedigree of Troilus and Criseyde may be briefly displayed in the form of a genealogical tree :—

Dictys Cretensis, *Ephemeris Belli Trojani*, (4th Cent. A. D.)

Dares Phrygius. *De Excidio Trojai Historia* (6th Cent. A. D.)

Benoit de ste. Maure, *Roman de Troje.*

Guido delle Colonne, *Historia Trojana*

Boccaccio, *Filocolo.* Boccaccio, *Filastrato.* "Lollius."

TROILUS & CRISEYDE.

The chief source is *Filostrato*, but Chaucer also shows first hand acquaintance with the other works indicated. As for " Lollius," there is no agreement as to who he was. The particular *Cantus Troili* ascribed to him (I. st. 57) is translated from Petrarch (Sonnet 88). But the most probable explanation is that he is a progenitor of Mrs. Harris.

Rossetti calculated that 2583 of the 8246 lines in *Troilus and Criseyde* are adaptations from *Boccaccio*. Yet the resultant poem is, in its essence, strikingly original. Neither poem is in any way Greek: Troy differs not at all from Paris or Rome; Priam or Agamemnon might as well be the King of France or the Emperor. The setting, the events, the characters, in all externals, all belong to the world of conventional mediaeval chivalry—a chivalry already decaying inwardly and become more elaborate outwardly. In *Boccaccio* and in Chaucer's other classico-chivalresque tale, of Palamon and Arcite, the persons remain mere denizens of this world, to the end of their story. They act according to the requirements of their plot and have no life outside it. But with Troilus and Criseyde and most assuredly with Pandarus, it is different. They come truly alive and in the imaginations of those who have the gift, may take

part in other scenes than those of Chaucer's five books.[1] This is why Chaucer's poem is so much slower in movement than Boccaccio's. When we read *Filostrato* our interest is centred on the expected consummation of the lover's passion. By what device or intrigue will Troilus achieve his end ? The end itself is regarded as certain, and Boccaccio has no great interest in the niceties of a woman's progress to an inevitable end. Pandarus is a mere agent in the plot, a figure typical, as Ker remarks in the passage already referred to, of the *Decamerone.*

Chaucer alters all this. The plot is no longer in itself of interest. He would not, one imagines, be perturbed at the thought that all his readers might already be acquainted with *Filostrato.* Character, not incident, is the poet's theme. How will Cressida be brought from this mood to that? How will love affect Troilus? How will Diomede move one already unsettled by Troilus ? We do not wish to hasten the course of the story; we take our pleasure in watching Cressida come slowly and naturally to the full acceptance of her lover. And this element is wholly Chaucer's. The portions of books II & III which treat of this are represented by barely a few lines in Boccaccio.

But the greatest addition is Pandarus, the first great comic character in English literature, ancestor of a long line, which must be held to include not only Shakespeare's Pandarus but also his Falstaff and Sir Toby Belch, and continuing to Tom Jones and the great Roy Richmond. Here we have a character new to mediaeval art, who while undoubtedly a bad man is not wholly bad and not at all unattractive. We condemn the sin while we love the sinner, and with all these folk we have the sympathy that arises from our realisation of their and our common humanity. Ker speaks of Chaucer as the forerunner of Fielding. It is, I imagine, of this mixed morality that he is thinking. Richardson would have had more fellowship with the "Moral Gower". I do not hesitate to compare Chaucer with a still later master, Meredith, by reason of the emphasis laid on the shades of feeling and thought of the characters at the expense of slowing down the action, beyond the liking of some readers. I feel even that Chaucer would have been interested to read Mr. James Joyce's *Ulysses.*

5.

It may be thought that I have said too much of Chaucer as anticipating the novelists: faint praise, some may think, of a poet.

1. Cf. Henryson's "The Testment of Cresseid," where Cressida cast off by Diomede and stricken with leprosy begs of the faithful Troilus, and is unrecognized.

But there is no question of Chaucer having used the wrong medium. In the first place, Chaucer was a bad prose writer. His version of *Boethius* does not read well; his *Tale of Meliboeus* better, but dull; *The Parson's Tale* is still duller. Chaucer's verse is clearer, more varied in its rhythm, and more lively, not only than his own, but than any one else's prose for centuries to come. Secondly, this particular rendering of this particular tale gains enormously by being told in verse. It is not pure narrative; it is seasoned with comment, and varied by, as it were, the tone of the teller. The rhymes and rhythms, expected yet varied, give here a pungency, then a pithiness, and yet elsewhere suggest an intonation which English Prose even to-day, and certainly not before the late seventeenth century could hardly hint at. As well put *Don Juan* into prose. Chaucer never makes the mistake of aiming at a continuous heightened effect; therefore he is never flat, as Wordsworth often is, or, as Milton, pathetic. He works his emotion into whole passages, not into single words and phrases whose presence may elsewhere be missed. Four stanzas out of five he writes in an admirable middle diction, which he varies with passages of dry satiric wit blended often with a homely sententiousness deliberately lowering a little the tiresome, unbending dignity of conventional poetry,[1] and here and there rising to a note of tender sweetness[2] and even of a genuinely personal religious passion.[3] In all these passages we seem to hear Chaucer's varying tones and watch the subtle changes of his face. By the same skill, his snatches of dialogue[4] are admirably rendered, so that (another anticipation of the modern novelists) we could distinguish the speaker by the turn of the phrase.

Nor does Chaucer appeal only to our ears. Continually the scene moves before our eyes. Notice how, at the dramatic moments of his poem he vivifies the scene; at the first appearance of Cressida in the temple for example: and he brings Troilus before Cressida's eyes as he rides down the street, without much personal description but in a setting that is simple, natural and easily pictured.

The qualities which I have here indicated may all be paralleled from The Canterbury Tales; in that collection there is in truth "God's Plenty". But *Troilus and Criseyde* remains by far the greatest single poem of Chaucer; a very long poem but every line

1. For example, T. & C. Bk. I. Sts. 31, 32; 91; 116, 117.
2. For example, T. & C. Bk. I. Sts. 4, 5.
3. For example, T. & C. Bk. V. Sts. 263, 264.
4. For example, T. & C. Bk. I. Sts. 145-152; Bk. II. Sts. 13-20. Note that these passages owe hardly anything to Boccaccio.

of it developing a single theme, which the poet himself sums up at the close (Bk. V. St. 262):—

"Swich fyn hath, lo, this Troilus for love,
Swich fyn hath al his grete worthinesse;
Swich fyn hath his estat real above,
Swich fyn his lust, swich fyn hath his noblesse;
Swich fyn hath false worldes brotelnesse,
And thus began his lovinge of Criseyde,
As I have told, and in this wyse he deyde."

K. N. Colvile

A SHAKESPEARE CRUX

Long dissatisfied with the commentators' epexegeses of Twelfth Night iii, iv, 33 et seqq., I pounced upon the New Shakespeare Edition of the play as soon as it appeared in Bombay. The editors of this Shakespeare have cast real light into so many *Stygian Caves forlorn,* either in their commentary or in the hypothesized stage directions that intense study or happy inspiration has suggested to them, that I hoped they would solve my problem in this passage.

The passage occurs in the scene where the hoodwinked Malvolio tries to put into practice the graces that he thinks his mistress has enjoined upon him. *The Fortunate Unhappy* had commended his yellow stockings, commanded him ever to be cross-gartered and besought him as he entertained her love, to let it appear in his smiling that so well became him. His conduct is strange in the eyes of Olivia. Here is the passage of which I seek the solution. I quote the New Shakespeare Text.

Olivia—Why dost thou smile so, and kiss thy hand so oft?

Maria—How do you, Malvolio?

Malvolio—(disdainful)—At your request! Yes, nightingales answer daws.

From the stage direction *disdainful* it is clear that the editors think that Malvolio addresses the following remark to Maria. Their comment is 'i.e. What? Am I to answer questions from such as you?'

This is the hackneyed explanation, but it seems scarcely worthy of this edition. In a Shakespeare play, one has to be very circumspect before applying the principle *post hoc ergo propter hoc,* for it is far from true that every utterance is the answer to the utterance that precedes it. The New Shakespeare explanation of these words has at first sight the advantage of presenting us with a Malvolio who is being 'surly with servants.' But a closer examination of it shows that its disadvantages are more than counterbalancing. It offers no explanation of the words '*yes, nightingales answer daws.*' It does not attempt to explain why the Malvolio who is trying to be 'surly with servants' uses the polite plural 'your' when speaking to his inferior, Maria. It fails to note that, however withering be the surliness of this reply to Maria's polite inquiry, a much more effective way of being contemptuous is to ignore her query altogether.

Strangely enough the New Shakespeare editors tantalisingly play with the idea which contains, I think, the clue to the solution of this problem. Thus they say on vv. 24-5, 'Maria nowhere else "thous" Malvolio,' and on v. 52, 'Part of the humour of this dialogue (lost on a modern audience)—consists in Malvolio "thouing" his mistress so freely.

Both of these remarks are sound, but unfortunately, I am afraid, the explanation of vv. 33 et seqq., which this edition offers, shows that modern editors as well as modern audiences sometimes miss the distinction between thou and you.

If it be clearly remembered that the Elizabethans observed a very definite distinction between thou and you, the passage becomes, I submit, fairly clear. Olivia addressing her steward naturally "thous" him. Maria, a serving woman, to the major-domo uses the respectful 'you.' Malvolio, in accordance with the dictates of his own heart and the directions of the Fortunate Unhappy, surlily ignores Maria's question and answers Olivia in the respectful plural 'you.' Olivia has asked him why he smiles so much. Her question puzzles him because the explicit injunctions of her letter are ringing in his ear. He makes the natural reply 'at your request,' i.e., I am smiling and kissing my hand like this at your request. This baffles Olivia who is in blissful ignorance of the correspondence of the Fortunate Unhappy. She is astounded at Malvolio's impudence in making such a suggestion. Her face shows her surprise, but, before her lips can utter it, Malvolio reiterates his explanation with an emphatic 'yes.' Further to substantiate his assertion and somewhat to palliate his mistress's apparent frowardness he falls back upon an example culled from the Euphuistic quasi-natural history so popular at the time. The nightingale for countless generations had been the exemplar to the world of the female mourner of a domestic grief, like that of Olivia. Yet even this grief-lorn bird like all the other fowls answers the call of 'the spring time, the only pretty ring time' even if, as here, she has been reminded of Spring's advent (and appeal) by the voice of the daw whose dark feathers are almost as forbidding as the black apparel of a puritanical steward.

H. HAMILL

LITERARY IMPOSTURE

Till man by personal endeavour or grace divine attains to the Absolute Good, his notion of good here below is as inextricably associated with evil as substance with shadow or matter with form. Despite the light of science and civilization human nature remains much the same as it was, and no department in which human energy has been manifested is without its peculiar limitations and drawbacks. Literature is a record of the noble thoughts of master minds couched in a style which enthralls the reader as much by the beauty of its expression as by the profundity of the idea it embodies. Yet in literature too people have passed off their own flimsy stuff under the names of departed worthies or have electrified their age by announcement of an important find, which after all is the dishonest product of their own minds. Imposture feeds and grows on credulity, and so long as there are people anxious to devour all that is novel or sensational without pausing to probe the merits of what they read, literary deception can still be assured of a long though ruinous career. Fame much more than pecuniary gain has rendered some people deaf to the still small voice of their conscience and egged them on to mislead the world by their duplicity. Impostures have particulary flourished during the restoration of letters, and one favourite method of roguery was to bury spurious antiquities which might afterwards be brought to light to confound the public. But evil is always shortlived, and very often in his own life-time the culprit sees the bubble of his vanity pricked by the shrewdness of a critic, and he is brought to his knees to confess to a disillusioned public the sordid story of his deception. These impostors seem to forget the truth so pithily expressed by that great but simple soul, Abraham Lincoln :—You can cheat the whole world for some time, or part of the world for all time ; but you cannot deceive all the world for all time. Though Dr. Jekyll and Mr. Hyde will always be found racing about in the field of letters as in all other departments of human energy, we shall here only take note of several prominent instances of deception perpetrated particularly in English literature.

We shall do well to turn to the smaller fry in the beginning. Daniel Defoe was a born intriguer, and Prof. Minto calls him "a great, a truly great liar, perhaps the greatest liar that ever lived." He saw service for ten years under different governments, becoming a Whig

with Whigs and a Tory with Tories, and trying to serve two masters by espousing the cause of the fallen Stuarts while he was in the secret pay of the Whig Government. His veracity in his "Journal of the Plague" is often impeached. "Robinson Crusoe", which came out in 1719, was entirely based on the real adventures of Alexander Selkirk who had stayed for four years in the island of Juan Fernandez and had returned to England in 1711. But such was Defoe's notoriety for dishonesty that he is said, on extremely doubtful authority however, to have antedated his work at 1704 so as to make it appear that it could not be indebted to the career of Selkirk. Pope was another tricksy unscrupulous person, and as Prof. Courthope observes in his great life of the poet, he antedated his "Essay on Criticism" in the hope of being considered a precocious genius. In his translation of the "Odyssey" Pope sought the help of two other poets, Fenton and Broome, who did a good part of the work and did it remarkably well. Pope was however dishonest enough to suppress their names completely and pocket the lion's share of the profit. But the public in due time saw through the trick, and a humourist wrote the following verse with a pun on the name of Broome :—

> "Pope came off clean with Homer, but they say
> Broome went before and kindly swept the way."

Returning to Defoe, we find he was always ready to seize the opportune moment and was thus able to bamboozle the public by his wonderful habit of "lying like truth". When a report reached England that the island of St. Vincent was blown up in the air, Defoe wrote a bogus description of the calamity, which he considered the greatest since the Flood. It was a tissue of lies, but the public swallowed it with avidity. When the notorious highwayman Jack Sheppard was at last arrested and sent to the gallows, Defoe judged from the public excitement that if a thrilling narrative of his life be prepared, it would sell like hot buns, for people were not then in a mood to scrutinize the facts and figures of his career. And Defoe proved himself equal to the occasion; he got up a highly spiced biography of the highwayman and gave it out as if it was written by Jack himself. Nay, Jack was induced to announce from the gibbet this pamphlet as his last will and confession! Defoe has also written the history of a terrible storm in minute detail, quoting entirely spurious letters in support of his statements. This work is as wanting in authenticity as his "Journal of the Plague". Sometimes by an entirely misleading heading of a certain work, he deceived the public, and then disappeared for a time to escape the consequences of their fury. His well known political pamphlet

"Short Way with Dissenters" is one of the best illustrations of irony in English literature. It was in fact not an onslaught on the Dissenters at all but on the Highchurchmen, who were so far deceived as to hail it with acclamation though the shafts were actually levelled against themselves. When the truth became known, he was arrested, fined and put up in the pillory, where he was covered, not with garbage but with flowers by his sportive admirers.

This love of sheer mischief for mischief's sake is also to be seen in Dean Swift. In his times a cobbler named John Partridge had set himself up as an astrologer and published numerous almanacs. Swift, under the pseudonym of Isaac Bickerstaff, brought out his own predictions in which, among other startling things, he foretold the death of Partridge on 29th March 1708 at 11 P. M. After that date Swift quietly announced the death of Partridge who hastened to assure all of his existence. But Swift now published his " Vindication " in which he tried to make it clear that his prophecies were based on the soundest calculations and that the cobbler had certainly breathed his last. All the wits and wags of the country now took part in this tomfoolery at poor Partridge's expense, till the public were thoroughly wearied of this joke which went on for two long years. Another freak of this madcap creator of the Yahoos was his poem on "The Death of Dr. Swift," full of that ghastly humour which was so often characteristic of his work. By this feeler he perhaps wanted to know how the information of his own death would be received by various classes of society. Isaac Disraeli, that indefatigable collector of literary odds and ends, quotes in his "Curiosities of Literature" the instance of George Stevens, the Shakespearean commentator, who had a grudge against the famous antiquary, Richard Gough. Stevens was a terror to his friends and was fond of playing malicious practical jokes upon them. Though he had taken a leading part in exposing the literary forgeries of his day, Stevens took it into his head to befool Gough as well as the whole Society of Antiquaries. With this view he got up a tombstone on which was engraved the drinking horn of Hardyknute to indicate his last fatal carouse, since this king is reported to have died when in his cups. The mischief-monger took good care to see that the inscription was in Saxon characters and sufficiently legible. It was steeped in pickle to give it the apearance of antiquity, and the tombstone was deliberately raised in the corner of a broker's shop frequented by Mr. Gough. The plot succeeded only too well; the antiquary was led thoroughly astray, but he never forgave Stevens afterwards for thus playing a hoax on him in public.

Persons whose fame is already secure by virtue of their high birth or literary attainments have often stooped to earn cheap noto-

riety by exceedingly doubtful means. Mr. George Dawson in his "Shakespeare and other Lectures" refers to Horace Walpole, the prince of English letter-writers, who published the "English Mercuries," which, as he gave out, consisted of pamphlets written in times of Queen Elizabeth. But the forger forgot that his papers bore the watermark of G. R., and George Rex could not of course have flourished in the days of Queen Bess. This discrepancy decisively settled the matter against Walpole.

There are certain cases of spuriousness, devoid, however, of all deliberate imposture, which have been the subject of long, bitter and memorable controversies. One of these cases was regarding the notorious "Epistles of Phalaris," which brought into prominence the capacious scholarship and fierce pugnacity of Richard Bentley. Phalaris, tyrant of Agrigentum in Sicily, whose name is always associated with the brazen bull in which he roasted offenders to death, is said to have been the author of 148 Greek letters, whose genuineness has been frequently called into question. When Charles Boyle published his edition of "Phalaris," he was contemptuously criticized by Bentley. But all the scholars of England took arms against the latter, and Boyle with the help of Atterbury and Aldrich wrote a thesis which, it was thought, had finally silenced Bentley. A caricature was published in which Phalaris was depicted as consigning Bentley to the bull, while the great scholar was made to say: "I would rather be roasted than boiled (Boyled)." But after two years Bentley came forward with his famous "Dissertation", giving the most irrefutable proofs, expressed in his usual disdainful manner, of the spuriousness of the Epistles, thereby winning over all the learned men to his side. This great controversy which had been begun in 1692 by Sir William Temple closed in 1704 when Swift burlesqued the whole contest as well as the combatants in his "Battle of the Books."

We had now better turn to the big guns of literary fraud. George Psalmanazar, whose real name remains unknown, is perhaps the greatest of impostors and practised deception on an epic scale. In the early years of the 18th century he visited the island of Formosa which was then but little known except through the reports of the Jesuits. Such were his astounding cleverness and impudence that he now got up an entirely imaginary work on Formosa, giving its social life, manners, customs, religion, rituals, history, geography, a strange calendar and a wholly novel language and grammar of that country! The book also contained illustrations of houses, temples and other noteworthy things of Formosa. He was patronised by Dr. Compton, Bishop of London, to whom he dedicated his

work. The scholars were entirely deceived and Formosa appeared in the maps as a real island in the spot Psalmanazar had indicated. But the lacunae in his prodigiously bold undertaking now gradually began to appear on closer study. Though he had got up a whole alphabet for Formosa, he actually forgot to give names to his letters, which discrepancy puzzled him before his critics. He had been shrewd enough to observe the utmost consistency and had resolved never to change what he had once given out, but this attitude sometimes landed him in a predicament. He had inadvertently affirmed that the Formosans sacrificed 18000 male infants annually. He persistently refused to lessen the number though it was evident to all and even perhaps to himself that this tremendous annual loss would surely occasion a depopulation on the island.

He now had the misfortune to form the acquaintance of a clergyman named Innes, who being a rascal himself soon sounded the rascality of Psalmanazar. Innes gave Psalmanazar a passage from Cicero to translate in his Formosan language. After a few days he procured from Psalmanazar another version of the same passage, and both versions were found to be materially different. Psalmanazar had a most retentive memory, but the uncanniest memory in the world would not have translated the same passage twice into an entirely bogus language without falling into serious errors. But when the fraud was detected, Innes exploited Psalmanazar and made him the ladder of his own ambition. It was by advice of Innes that the great "History of Formosa" was written and advertised on a large scale, Psalmanazar being given by the artful clergyman only £ 20 for the work which must have taxed his energies to the utmost. To set a premium on his iniquity, Psalmanazar challenged and refuted certain accounts of preceding travellers, and for the time being his work was regarded as an authority on the subject. But now Psalmanazar met another bird of the same feather who persuaded him to father a composition called the "Formosan Japan," which was to be sold at a high price. The failure of this work which was full of mistakes suddenly opened people's eyes to the spuriousness of the "History of Formosa" itself. Psalmanazar found that his ingenuity in fabricating facts and figures had exhausted all its resources, and he now made a clean breast of all his impostures regarding Formosa. This deception was satisfactorily exposed only when Psalmanazar, after having fooled the best authorities on the subject, chose to repent of his transgression. Even now there were people who took his confessions to be but an index of his great humility. How "some people can be deceived for all time" can best be seen from the

words of Dr. Johnson, who held the moral character of this forger in such high esteem as to remark that Psalmanazar was the best man he had ever known.

Literature has its born forgers as well as its born poets, and some there be who have shown from their tenderest years a tendency to gull the public by their misguided ingenuity. Such a person was Thomas Chatterton, and it was this evil habit that got the better of that "marvellous boy" and led him to "perish in his pride." While yet a child, he deceived a poor pewterer named Burgum by proving his noble birth through the fabrication of several papers. He then forged an imaginary account of the opening of Bristol Bridge in the times of Henry II, which completely took in the local authorities. Emboldened by his success, Chatterton wrote a mass of pseudo-antique poems, consisting of epic fragments and dramatic lyrics, and claimed them to be the work of one Thomas Rowley of Bristol, who, he said, flourished in the reigns of Henry VI and Edward IV. A good many people were deceived by the forgery of the Rowley papers; Horace Walpole was one of them, but finding matters a bit doubtful, he sent the papers to his friend Thomas Gray, whose Ithuriel spear soon detected Chatterton lurking about in the guise of Rowley. The boyish offender in attempting to write the language of the 15th century had fallen into grievous blunders. He had consulted a bad dictionary, and his misspellings and grammatical slips could only be matched by his faulty metres and anachronisms. Nor was he always able to employ a consistently antique style. According to Mr. Theodore Watts-Dunton, his forgery was not inspired by a mercenary point of view, nor was it the result of a masquerading impulse, but rather the impulse of a truly artistic nature to excite interest and controversy in his own production. We are unable to take so charitable a view of this serious matter, for which there can be no reasonable apology except the boyish age of the offender, who, in thinking that he was deceiving the world was only deceiving himself. But it is to be remembered that Chatterton was a juvenile prodigy. He exercised considerable influence on his successors, and in leading people's minds, however falsely, back to Mediaeval times, he gave a great impetus to the Romantic movement, which was then struggling in its birth. So great a critic as Sir Edmund Gosse considered Chatterton the most extraordinary phenomenon of infancy in the literature of the world, and held that had he lived 20 years more and obtained suitable training, his place would have been with Milton and perhaps with Shakespeare. But it is lamentable that this "inheritor of unfulfilled renown" should have taken to dishonest ways from the very beginning and then out of grief and morti-

fication laid violent hands on himself before he was out of his teens.

Deception has often assumed strange disguises to compass its ends. Goaded by self-interest it enables the evil-doer to pose as an original author or a great discoverer ; it may also tempt him to pass off another's work as his own and even to run down a great author unfairly just to win the merit of being the first to show that that eminent writer had often shone in borrowed plumes. In 1747 William Lauder, a school-master and a sound classical scholar, startled his readers by an article in the "Gentleman's Magazine" showing that Milton's " Paradise Lost " was largely constructed out of passages plagiarised out of Latin authors. Owing to the vast scholarship of Milton, the "Paradise Lost" is redolent with such a perfume of literary reminiscences that Lauder was for a time able to lead the people astray by his miserable tricks. Not satisfied with pointing out resemblances between the real passages of Milton and those of his Latin authors, Lauder had the audacity to forge verses closely resembling those in " Paradise Lost " and ascribe them to older poets. Villainy waxes strong with success, and Lauder now extracted several lines from William Hogg's Latin version of " Paradise Lost ", published in 1690, and inscribed them in the Latin works of Massenius, Staphorstius and others, thus presenting such passages as the literary larceny of the great Puritan poet. Dr. Johnson, who is hardly fair to Milton, espoused Lauder's cause and wrote a preface to the impostor's " Essay on Milton's Use and Imitation of the Moderns in his 'Paradise Lost' ". But to Lauder's misfortune there were shrewder critics in England like Dr. John Douglas, Bishop of Salisbury, " the scourge of impostors, the terror of quacks " as Goldsmith hails him in his " Retaliation ". Bishop Douglas' exposure of the man and his methods was both thorough and complete ; the forger made some futile attempts to clear his character, but finding it too hot to abide in England, emigrated to Barbados where he died in obscurity in 1771.

Two instances may now be quoted of misguided writers who tried to seek a bubble reputation by pretending to have made valuable discoveries in the works of Shakespeare. William Henry Ireland was endowed from his early years with a veritable genius for lying. At first he tried his prentice hand in the creation of fabricated documents; he pretended to have discovered a letter from Shakespeare to Queen Elizabeth, another from Anne Hathaway to her husband, a love-epistle from the great dramatist to his wife with an enclosed lock of hair, and a mortgage deed said to have been made between Shakespeare and John Heminge on the one part and Michael Fraser and his wife on the other. Many

more such documents were forged by the youthful Ireland who thereby deceived his father Samuel Ireland, a man whose own methods were never unquestionable, but who was now completely taken in by his more rascally son. The elder Ireland exhibited these documents publicly at his house and invited scholars to inspect them. Many were deceived and Boswell with his usual hero-worshipping instincts is said to have kissed the supposed relics on his knees. Finding that his sins had passed undetected, the younger Ireland forged in the name of Shakespeare, a blank-verse play named "Vortigern" based on the reign of an ancient English king of that name. The play was represented at Sheridan's theatre and so vast was the difference between the language of the Elizabethan giant and his dwarfish 18th century imitator that it was immediately hissed out. In Act V, Scene ii, Kemble had to recite "And when this solemn mockery is o'er"; on hearing this unfortunate line, which was an appropriate though unconscious commentary on the play itself, the audience broke into fits of obstreperous laughter, and the play was irretrievably damned.

But the younger Ireland's ardour for dishonesty had not cooled as yet, and finding that his forgeries had so far passed muster, he reached his crowning iniquity in his declaration that his own ancestor and name-sake Mr. W. H. Ireland had once saved Shakespeare from drowning and had been consequently rewarded by the dramatist with all the manuscripts which had just been brought to light. We fail to understand why the forger should have desisted at this stage, for he could have as well identified the initials of his supposed ancestor with the immortal "W. H.," the "onlie begetter" of the Shakespearean sonnets! That would have been a capital hit, but even as it was, Ireland had now gone beyond his depth. Malone smelt the rat and mercilessly exposed the man. When all was lost, Ireland confessed the forgery and wrote in 1786 an "Authentic Account of the Shakespearean Manuscripts." The position of the father, who all along believed in their genuineness, became extremely awkward, and he replied by a "Vindication." But the people now had enough of the father and the son whose quarrels were never reconciled. The father felt the disgrace bitterly and it probably hastened his own end in 1800. In 1805 the remorseful son appeared again with his "Confessions," entirely exculpating his father from the fraudulent business of which he, the son, was the sole projector. The latter met with his deserts, sank into poverty and died in 1835.

Another person of that ilk was John Payne Collier, a man of acknowledged merit, who unfortunately sacrificed the enviable reputation he had earned in the field of Shakespearean investigation

to his fatal propensity for forgery. As librarian to the Duke of Devonshire he had access to the chief collections of early English literature, but he misused these opportunities by bringing out in 1852 a forged volume, notorious as the Perkins Folio, from the words "Tho. Perkins his Booke" inscribed on its outer cover. This book contained, as Collier said, emendations on Shakespeare from the hand of "an old collector." The fraud was first exposed by C. W. Singer and others followed suit. Collier in his replies made matters worse by numerous contradictions and dubious assertions. Still such was the respect in which he was held by scholars that the great Shakespearean J. C. Halliwell-Phillipps refused till the end to believe that Collier, his own senior colleague and guide, could have ever knowingly misled the world of letters. But after Collier's death certain manuscripts were discovered showing that he was actually guilty of forgery, his case remaining a woeful instance of literary fraud, perpetrated by a person from whom such an action had never been anticipated.

We have taken note of traitors in the realm of Minerva, betraying the cause of learning for the sake of short-lived fame; but there are brokers in her kingdom also—men of straw who earn a dishonest living by making others, who are far more intellectual, drudge for themselves. Sir John Hill once contracted with a bookseller to translate Swammerdam's work on insects for 50 guineas though he did not himself understand a word of the Dutch language. Sir John then bargained with another translator to do the work for 25 guineas, though this second person was as innocent of the Dutch language as the knight was. Then the second man set out in search of a translator and happened to come across a scholar of the Dutch language who was prepared to undertake the work for 12 guineas. So the two ignorant "translators" got the best of the bargain, while the modest scholarly drudge, whose very name is unknown to the world, broke his daily bread in peace and preferred to remain in oblivion. Verily, the disagreement between the Goddesses of Learning and Wealth as described in Hindu mythology is as transparent in actual life as it is deplorable.

But there are certain dishonest men of letters who are treated with undue severity by the critics. In reproducing fragmentary ancient ballads or epics, the editor or translator has to fill up the gaps by lines of his own invention if he does not wish the work to appear scrappy and disjointed. A scrupulously honest man would certainly indicate what is original and what is his own independent work; but in case he fails to do so, it would indeed be overharsh to condemn his whole work as forgery. Between 1760 and 1763 James Macpherson published certain fragments of Gaelic poetry in

the form of two epic poems "Fingal" and "Temora", supposed to have been written by Ossian, the Scottish warrior-bard of the 3rd century. "Fingal" was dedicated to Lord Bute, a man who, despite all the faults that Lecky has attributed to him, was endowed with literary tastes, and the publication of "Temora" was entirely financed by the same person. The patronage of this Scottish nobleman, who was the best hated man in the kingdom in those days, affected Macpherson's case unfavourably from the very beginning. The poems were attended by certain suspicious circumstances and were denounced by Hume and Dr. Johnson. Macpherson lost his balance and threatened Johnson with personal chastisement, when the latter, never more happy than when he accepted a good offer, promised to meet his opponent at the appointed place with a stout oaken staff surmounted by a leaden knob as big as an orange. Though the expected fight never took place, long and tedious wordy duels have been held and a great deal of ink has been spilt over this controversy. Shairp and Blair think "Ossian" genuine ; Saintsbury, Gosse and Courthope are inclined to think otherwise. In fact there are Davids of the one and Goliaths of the other.

But after all there are certain charges going heavy against Macpherson who was unable to reply to them. In the first place Macpherson professed to have translated his work from Erse manuscripts collected in the Highlands. This was certainly untrue, and he never produced them when challenged to do so nor were any found in his papers after his death. The poems do not breathe the atmosphere of antiquity, for the Gaelic language is pure and simple while Macpherson presents us with a rhapsodical prose-poetic diction ; nor do we get a vivid picture of the social life of the times from the work. But it would be unjustifiable to dismiss the whole work as forgery because Macpherson could not have written so much original poetry in such a short time. The Ossianic works were in fact based on local traditions gathered orally from the villagers as Dr. Elias Lönnrot in the last century edited the "Kalevala" from songs and legends collected from the peasants of Finland. But Macpherson deserves to be censured for having got up the fib of the Erse manuscripts which he said he had translated. He may have been constrained to supply certain gaps in the story by materials of his own invention, but it is very difficult to say how far his work is based on genuine local tradition and how far it is due to his editorial ingenuity. Though some of Macpherson's methods are undoubtedly questionable, we would be doing him gross injustice if we condemned as a fraud his entire work, which, by the way, fascinated such great minds as Goethe

and Napoleon, and exercised considerable influence on the Romantic movement in Europe by opening up an entirely novel region for exploration.

Thus we see that all forms of deception are not to be condemned equally. In certain cases the author, being a young man or writing his first book, is anxious to appear before the public in a novel guise and to let his readers know that he at any rate has nothing to do with the work. There are authors who under stress of poverty have sold their names to be prefixed to works they have never written, while some writers, anxious to flatter their noble or royal patrons, have prefixed the latters' names to their own productions. In several cases the writer is himself deceived while he appears to others as if he was deliberately trying to fool his readers. Sir John Mandeville of the 14th century has been recognised, with certain reservations, as the father of English prose. He travelled for 30 years and more, and then described his exploits in Latin, French and English. His work is extremely interesting but consists of the most incredible fibs ever set going by travellers in times when adequate means of communication with distant countries did not exist. It is a typical "traveller's tale", but it is impossible to determine the *mens rea* of the author or to say how far he cheated the public, or was himself deceived by the strange countries and their curious ways and customs, which lend themselves easily to misinterpretation at the hands of foreigners. His very guides may have bewildered him in certain respects and filled his mind with mysterious and magical happenings. He has strange things to say about Prester John, the Phoenix, the Upas poison tree, the cave where Adam and Eve dwelt, the land exclusively peopled by the Amazons, dog-headed cannibals, and the hills of gold at Taprobane, frequented by pismires as big as hounds! Mandeville's work is also far from original, for he has freely pilfered from the preceding historians between whom and him in point of veracity there is little to choose. All this is certainly inexcusable, but as biographers suffer usually from the Lues Boswelliana, so too travellers of olden days were often victims to exaggerations, prejudices, superstitions and miracle-mongering; and though their work would tend to deceive the public, still the latter were generally too shrewd to take for gospel truth what was only recorded in a book of travel. If Mandeville be contrasted with Psalmanazar, it will be easy to see an almost unconscious fooling of one's self as well as others in the one man, and a conscious and deliberate attempt of the other to delude people by a wholesale and colossal fabrication of things for which no basis existed whatsoever.

The acid of satire is often necessary to wipe out the stains of

untruth and exaggeration to be found in such tales of travel. In 1785, Rudolf Erich Raspe, a German fugitive living in Cornwall, wrote his funny "*Baron Munchausen*" being a volume of travels in which the hero meets with the most marvellous adventures. The work, which is compiled from various sources, is said to be (though not unanimously) a satire on the "*Travels in Abyssinia*" by the famous Scotch explorer James Bruce, whose work appeared almost romantic in its novelty to his age. We cite below only a few of Baron Munchausen's ridiculous adventures:—In Russia the cold was so intense and the snow fell in such mountainous heaps that the Baron tied his horse to a church-steeple; but when the snow melted, the poor animal was found hanging in the air. Once the Baron shot a stag in the head with a cherry-stone and in a year a tree grew out of it, which the animal carried about wherever it went. The Baron's clothes being once bitten by a mad dog went mad; and so on. It should seem that this sort of stuff either came out from the head of a rather imaginative schoolboy, or, what is more probable, that it should have been aimed as a satire against the spicy tales usually related by travellers. What "Don Quixote" was to romances of chivalry, that, we are inclined to believe, was "Baron Munchausen" to books of travel.

Among other instances of "innocent imposture" (if such a contradiction in terms be permissible) we may mention cases of writers whose object was not so much to delude people but only to practise fun on them and raise a cheerful laugh at the detection. Mr. W. J. Long in his *Outlines of American Literature* cites the instance of the famous writer Washington Irving whose "*Knickerbocker History*" was a playful literary fraud on the public. Having come across one Dr. Mitchell's rather grandiloquent work—"*Picture of New York*," Irving resolved with the help of his brother Peter to burlesque it and begin right up from the creation of the world. He thereupon professed to have discovered the notes of a learned Dutch antiquarian, Diedrich Knickerbocker, who had left an unpaid board bill behind him. Irving advertised in the papers for the missing man (who of course never existed) and then announced to the public that he would himself publish the manuscript of the antiquarian, the proceeds going partly to the defraying of the bill. This literary hoax created quite a sensation, yet nobody was any the worse for the joke.

Sometimes a writer attempting an absolutely novel theme is so overpowered by lack of self-confidence as to let the people know that he is only editing a certain work that happened to fall into his hands. Our distinguished scholar, Mr. F. W. Bain, ex-Principal of

the Deccan College, will ever be remembered, among other things, for his delightful Hindu tales, light as gossamer, soft as the eider-down and woven from such stuff as dreams are made on. Who would ever wish to get out of that dreamland of love and romance, that cloudcuckootown where youth and beauty exercise their perennial charm, and "where the virgins are soft as the roses they twine"? In the introduction to his "*Digit of the Moon*" Mr. Bain refers to an old Maratha Brahmin of Poona, dying of the plague and handing him over his precious manuscript for publication. For a long time Mr. Bain pretended that he was merely translating into English the stories written by the Brahmin; and so sound was his scholarship in Hindu literature, mythology and religion that the delusion continued to beguile people for years. It was then discovered that Mr. Bain, working with a mind saturated in Hindu lore, was wholly its author. Mr. Bain himself says in the introduction to his "*Substance of a Dream*"—"But who writes them? I cannot tell. They come to me, one by one, suddenly, like a flash of lightning all together; I see them in the air before me, like a little Bayeux tapestry, complete from end to end, and write them down hardly lifting the pen from the paper, straight off 'from the manuscript.' Who can tell? They may be all but so many reminiscences of a former birth." Here 'from the manuscript' must mean the manuscript of the English author's own invention and not that of the Maratha Brahmin, who proved to be as illusory as the heroes of Mr. Bain's own stories, vanishing into thin air at the final approach of Shanker and Pârvati. But why write these tales, so tender and yet so passionate, so romantic and yet so wise, and attribute them to an imaginary Brahmin? Was this done with a view to deceive the public? Assuredly not: for a man would stoop to deception only when he finds it to his own advantage. But here the case was just the reverse. Our interpretation of the matter is that this was a piece of "innocent imposture," either due to Mr. Bain's diffidence in triumphing in the field of Sanskrit lore, or his genuine humility in passing off as a mere translator when he was actually the original author of the work.

When authors write in a foreign language or attempt an exotic theme which is to be embodied in foreign forms and imageries, it seems natural for them to conceal their identity till they are sure of success. Such writers either command a glorious triumph or court a ridiculous failure, and fear of the latter consequence compels them to remain concealed till they are tolerably sure of success. Dr. Sir Muhammad Iqbâl in his Urdu Introduction to his beautiful Persian poetical work—the "*Payam e Mashriq*"—traces the influence of Goethe's "*West Eastern Diwan*" on subsequent

German writers, among whom he cites the case of Friedrich Martin Von Bodenstedt, who stayed in Tiflis and acquired a wonderful mastery over the Persian language. In 1851 Bodenstedt published a German work called "*The Poems of Mirza Schaffy*," which is thoroughly oriental in form and colouring. The volume met with such vast success that in a short time it ran through 160 editions. Bodenstedt, who is also responsible for his excellent versions of Hafiz and Omar Khayyam, had so skilfully assimilated the spirit of Persian poetry that, according to Sir Muhammad Iqbâl, the poems of the imaginary Mirza Schaffy were long believed to be the translation of some real Persian poet. If this is deception, it is certainly an innocent one, for Mirza Schaffy never existed outside the German writer's imagination. If however a great Persian poet of that name had actually existed, Bodenstedt might have been blamed for deceiving the public by passing off his own poems under the cloak of an eminent personality. The case of Häring, the German Scott, stands on a different level. Häring imitated Scott and passed off his imitations as actual translations. So clever was his deceit (for deceit it was pure and simple) that, as Mr. J. G. Robertson observes in his "*Literature of Germany*," one of these imitations was actually translated into English and presented to the English public in all good faith as a hitherto unknown romance by W. Scott! This was indeed going too far; Scott is no denizen of the cloudland of the writer's fancy as Mirza Schaffy was, and cleverness does not deserve the name if it lapses into deception.

Another incident of "innocent imposture", celebrated in English literature, is associated with the great name of Thomas Carlyle, who, with an ingenuity reminding us strikingly of Washington Irving and Mr. Bain, explained the origin of his "Sartor Resartus" by a quizzical little story which was as false as it was interesting. Carlyle gave out that a German Professor named Teufelsdröckh had written a work called "*Die Klieder*" (the clothing), which was brought over to England by one Herr Heuschrecke. Carlyle found the book in an entirely confused state and promised to re-edit the work, which was named by him "The book re-edited" or "The tailor re-patched" (Sartor Resartus). It was one of his early yet ambitious works, and the author was neither sure of his own success nor of the popularity of his views. He consequently thought it safe to get up an eccentric German bookworm of a Professor and father all his philosophy and satire on him. The disguise was not difficult to penetrate; Teufelsdröckh was none else but Carlyle and the work remains a spiritual autobiography of the whimsical sage of Chelsea. It is easy to be satiric when we are enveloped in anonymity or wear a fantastic mask. Hamlet knew

his business, and realised that the darts of his invective would work a deadly effect on his victims when discharged under the convenient pretence of mental derangement. Works like "*Utopia*", "*Gulliver's Travels*" "*Erewhon*" etc., aim to deceive none but enlighten many by the wisdom that peers beneath the capricious surface. There is no attempt at deception, for instance, in Goldsmith's "Citizen of the World" and Montesquieu's "Lettres Persanes", because they are books purporting to be written not by their authors but by a Chinaman and a Persian. It is rather a humorous and effective endeavour to see ourselves as others see us, for the follies and foibles of our society are more evident to foreigners than to the most captious of our own critics.

We have now tried to discuss what is literary fraud, what is prompted by pure love of mischief, what is "innocent imposture", as well as who are the minor offenders and who its hardened criminals. The border-line between innocence and guilt in this department is very faint, and the same instance may be condemned as guilty by the one and let off as innocent by the other. Who can say, for instance, whether Chatterton, after winning success as Rowley, had not a mind to reveal his own identity as did Mr. F. W. Bain? We must not also forget the adequate limits and restraint with which this question should be considered. It would be puritanical to object to anonymous and pseudonymous literature on the ground that the former savours of *suppressio veri* and the latter of *suggestio falsi.* There is nothing better than plain unvarnished truth, but if one chooses to remain unknown, it would be hypercritically unjust to tear the veil of anonymity and drag the unwilling author into limelight. The question of literary imposture is closely associated with that of plagiarism, the "art" of passing off others' property as one's own but the subject is wide enough to claim independent treatment by itself.

The one noteworthy feature most apparent in these forgers and fraudulent writers is their extreme dexterity, their subtlety of invention and their shifts and devices when they get into trouble. All great rogues are men of brains, and it is owing to their cleverness alone that we are inclined to overlook, though never to justify, their misdeeds. When Virgil was condemned by his friends for pilfering too freely from Homer, he challenged all to do so if they could, because, said he, it is easier to rob Hercules of his club than Homer of a single verse: and indeed both courage and cleverness are required to attain even a short-lived fame in literary imposture. The capacious memory and wonderful powers of invention of Psalmanazar, the subtlety and dexterity of the Ireland father and son, and the marvellous attainments and knowledge of Mediaevalism

displayed by Chatterton, must extort our admiration even when we feel that such great endowments were worthy of a far better cause. But all wrong-doers forget that in the long run dishonesty entails greater worries and taxes the human energies far more than can ever be done through an upright straight-forward course of action. Chatterton, as Sir Edmund Gosse observed, would have proved worthy in the fullness of time to occupy that seat on Parnassus that Milton held: such a person could have easily rivalled the glories of Keats, if only he had given up the thought of humbugging the world with his Rowley papers. If Psalmanazar had the ability to invent a whole sham civilization of a strange and foreign place in all its minutest particulars, with far less trouble could he have given us the "Canterbury Tales" in prose or created the Waverley series for the edification of his grateful readers. But this was not to be. Haunted by an evil destiny, they failed to turn their undoubted abilities to the best advantage even to themselves, and a deluded public has at last given them the treatment they deserve. Unless the world is to go to wreck and ruin, brilliance must ever yield to honesty and art to morality, for an ounce of truth outbalances a thousand pounds of falsehood, however daintily dressed or elegantly tricked out. There is no downfall so overwhelmingly deplorable as that of a highly intellectual man perversely choosing to tread the easy descent to Avernus, the return from which, as fabled by ancient mythologists, is difficult in the extreme. Intellectual incompetence is preferable to moral bankruptcy; better to rot unknown than to rise like the rocket in the atmosphere of falsehood and then fall like the stick into well-merited obloquy and oblivion. The subject of literary imposture must therefore form a regrettable chapter in the world of letters, indicating the disastrous consequences of misdirected genius.

FIROZE C. DAVAR

APABHRAṀŚA METRES

1. Broadly speaking there are two main varieties of Indian metre (I) Sanskṛta or the refined and (II) Prākṛta or the popular. In the former Varṇa or a letter plays an important part while in the latter Mātrā or the metrical moment is the more important factor.

2. The Vedic metres which represent an earlier stage of the Sanskṛta metres are as a rule Varṇa or Akṣara Vṛttas. All that is principally required in them is a certain number of Varṇas or Akṣaras in a line of a given metre; the quantity of these Varṇas does not matter; *i. e.*, in theory they may all of them be either short or long though in practice the poets show a tendency to employ short or long letters at particular places in a metrical line thus unconsciously producing iambic or trochaic rhythm. On the other hand, the classical Sanskṛta metres which were evolved out of the Vedic ones, require not only a definite *number* of letters in a metrical line but also a definite *quantity* of each of these letters. Writers on metre generally classify these metres according to the number of letters which they contain in each of their lines. Specific names like Uktā, Atyuktā &c., are given to metres containing one, two or more letters in a line. Thus a metre containing 26 letters in a line is technically called Utkṛti. Under each of these heads several metres are further given which though they contain the same number of letters in a line, show nevertheless a different arrangement of short and long syllables in each case. It is obvious that each one of these main varieties is capable of yielding a definite number of sub-varieties by means of permutation. This definite number is technically called Saṁkhyā and the method of finding it out is usually given in older works on metre; cf. *e. g.* V. J. S. in JBBRAS 1932, p. 10; Hemacandra, Cchandonuśasana, p. 49a, line 11 ff. From these numerous sub-varieties, however, only a few must have been actually used by poets and these alone came into prominence getting specific names like Mālinī, Upajāti &c. for themselves. It is indeed in this manner that the later *i. e.* classical Sanskṛta metres originated from the earlier Vedic ones. Their essential characteristic is still the same, namely the prominence of Varṇas or the syllables, but the great freedom of the Vedic metres naturally disappeared owing to the plentiful restrictions regarding the quantity of the letters to be empolyed.

3. As opposed to these, the Prākṛta or the popular metres were Mātrāvṛttas from the very beginning. The earliest among these is evidently the Gāthā which in its Sanskṛta garb is called the Āryā. In these metres, the number of Mātrās alone is what is important. The letters may be short or long according to the convenience and inclination of the poet. A short letter represents one Mātrā while a long one represents two as a rule. Sometimes, however, even a long letter (more usually ए or ओ) is made to represent only one Mātrā. The Mātrāvṛttas on the whole afford greater freedom to the poet than the Akṣaravṛttas and appear to be more suitable for singing. In singing, keeping of time is very important and keeping of time is possible only with Mātrās and not with the letters, since a letter does not represent a uniform unit. It is probably for these two reasons that the Mātrāvṛttas found favour with the Prākṛta poets who in the early days of Prākṛta poetry were evidently drawn from the masses. Music is a popular art and it is clear from the Sanskṛta dramas that Ārya or Gāthā which is the most ancient of Matrāvṛttas was usually used for the song which was to be *sung* by the Naṭī at the beginning. The Cāraṇas and the Śailūṣas who formed the dramatic companies were popular Prākṛta poets whenever they were poets at all, and probably composed these songs though in later days they may have been composed by the dramatists themselves. Any how popular metres *i. e.*, metres which were composed by uneducated bards for the amusement and enlightenment of the masses to which they belonged seem to have been musical from very ancient days.

4. Prākṛta metres, though I have called them popular, were not entirely controlled and developed by the popular poets in all the stages of their development. When the Prākṛtas became the literary and classical languages, even the learned Pandits composed in them and it is perhaps for this reason that many Prākṛta metres of the middle ages are not musical. They were invented and employed by the Pandits for literary purposes. But as we come down to Apabhraṁśa Poetry which for the greater part appears to have been written *for* the masses though not always *by* the popular bards, it becomes increasingly evident to us how the metres were intended to be sung to the accompaniment of a musical instrument which usually was a hand-drum. In many of them the beat of the drum which occurs after a definite period of time which is marked by a particular number of Mātrās, can be easily perceived as soon as we begin to sing them. Thus, for example, when we begin to sing the Pajjhaṭikā metre which is so vastly employed for narrative Apabhraṁśa poetry we are unconsciously inclined to keep the time by giving the beat after every 8 Mātrās.

5. Among the Apabhraṁśa metres there are also some which were undoubtedly employed for a dance. The Rāsa Krīḍā or the Garbā dance is a very ancient thing at least in Northern India. In this dance, time is kept with the help of two small wooden sticks called "Tipari." The strokes of these Tiparis guiding the rhythmic movements of the dancers are easily perceived while we sing some of the Apabhraṁśa metres. The Ghattā, which generally is employed in narrative poetry for the sake of variety appears to be the pioneer of all such dance metres, the most characteristic and important among which is the Madanagṛha, where the sudden turn which the dancers take at a particular stage becomes quite evident when the metre is sung.

6. In order to bring out these points clearly, I intend to discuss, in the following paragraphs, the principal Apabhraṁśa metres by analysing and arranging the contents of the Prākṛta Piṅgala and the Cchandaḥkośa of Ratnaśekhara. Both the treatises treat mainly of the Apabhraṁśa metres and are composed for the most part in the Apabhraṁśa language. Prākṛta Piṅgala is published in the Kāvyamālā series and also in the Bibliotheca Indica. My references are to the latter edition which, by the bye, contains three good commentaries. Cchandaḥkośa on the other hand is not yet published though its mss. are available in many libraries. I am publishing it for the first time in the Appendix from three good mss. The curious relationship between the Prākṛta Piṅgala and the Cchandaḥkośa which I shall discuss below is the chief reason why I have selected these two works for my purpose. Both appear to have been composed towards the close of the 14th century A. D., but the Cchandaḥkośa is perhaps the earlier of the two. The author of this small but important work is Ratnaśekhara, pupil of Vajrasena and the successor of Hematilakasūri of the Nāgpurīya Tapā Gaccha. According to a Paṭṭāvali, he was born in Sam. 1372 (cf. M. D. Desai's "Jaina Gurjara Kavio" II p. 759). His Śrīpālacaritra composed in Saṁ. 1428 and his Gunasthāna-Kramāroha composed in Saṁ. 1447 are published in the Devachand Lalbhai Pustakoddhar Fund Series, Bombay. His literary activities are thus to be ascribed to the second half of the 14th century of the Christian Era.

7. It is true that in the following discussion I am leaving out of consideration the very large number of the Apabhraṁśa metres given by Hemacandra in Chs. V-VII of his Cchandonuśāsana. I have done this because I have formed an impression from Hemacandra's pedantic treatment of his subject that his discussion of these metres represents rather the theory than the practice of the Apabhraṁśa poets regarding them. This impression is further strengthened by a comparison between the Cchandonuśāsana and the Kavidarpaṇa

which latter is a younger contemporary of the former. But I reserve the discussion of this point for my introductory remarks to the edition of Kavidarpaṇa which will be brought out soon.

8. The Prākṛta Piṅgala (PP.) in its first chapter, with which alone we are concerned, defines 40 principal Mātrāvṛttas with their sub-divisions. The first among them is the Gāthā, which is followed by Dohā the most ancient Apabhraṁśa metre after the Mātrā, and others. Cchandahkośa, (CK.) is a small treatise containing 74 stanzas, the first three of which are introductory and explain short and long letters as also the eight Akṣaragaṇas. The next eight stanzas define and illustrate the eight Varṇavṛttas which are made with each one of these Akṣaragaṇas singly. It should be noted that the Varṇavṛttas, when employed in Prākṛta and Apabhraṁśa poetry, enjoy its characteristic freedom, for very often two or even three short letters which are to be quickly pronounced are substituted for a long one and this practice is sanctioned even by PP. I. 5. When considered from the point of view of a Mātrāvṛtta, the first four of these are of the Pādākulaka type containing 16 Mātrās in each of their four lines, while the last three are of the Madanāvatāra type containing 20 Mātrās in a line. The fifth which illustrates a Nagaṇa is a peculiar metre which has only 9 letters and also 9 Mātrās in a Pāda. It is called Bahula. The Matrāvṛttas proper begin with v. 12, though the author defines five metres even among these which are really Varṇavṛttas. These are Somakānta and Pañcacāmara Nārāca (CK. 14-15), Dumilā (CK. 16), Mehāṇī (CK. 44) and Pramāṇikā (CK. 46). Excluding the Gāthā the author gives 30 real Mātrāvṛttas the last of which is the Padmāvatī (CK. 50). In vv. 51-70 the Gāthā and its sub-divisions are defined and illustrated, the same stanza containing both the definition and the illustration, while the last four stanzas explain the two Pratyayas *i. e.*, Saṁkhyā and the Laghugurukriyā.

9. We thus see that excluding the Gāthā, PP. defines 40 Mātrāvṛttas, while the CK. defines only 30. Among these 15 only are common and in this manner both together define 55 metres in all. The language used for the definition and illustration of them is the Apabhraṁśa and the natural conclusion to be drawn from this is that they are all Apabhraṁśa metres. In PP. the definition and the illustration are given in separate stanzas while in CK. they are given in the same stanza.

10. For the sake of convenience, I shall discuss these 55 metres under the following four heads:—(1) Sama Vṛttas, *i.e.* metres having similar lines of equal length. These may be further divided into (*a*) Dvipadī or metres of two lines, (*b*) Catuṣpadī or metres of

four lines, and (*c*) Ṣaṭpadī or metres of six lines; (2) Ardhasama Vṛttas, *i.e.* metres consisting of two equal and similar parts, which however, are made of dissimilar lines. These may be sub-divided into (*a*) Catuṣpadī, (*b*) Ṣaṭpadī and (*c*) Dvādaśapadī or the metres of 12 lines; (3) Saṁkīrṇa or the mixed Vṛttas which are made by the mixture of two entirely different metres; and (4) Prāgāthika or the strophic metres which are formed by the combination of stanzas in two different metres.

11. PP. and CK. together define 27 Samavṛttas in all. Among them there are only four Dvipadīs, namely (1) "Ullālaka", PP. 118, (2) "Śikṣā" PP. 158 (3) "Mālā" PP. 161 and (4) "Khañjā" PP. 164. Ullālaka is a very important metre. It seems to be very commonly employed by the bards and the name Ullālaka was given to it by them (cf. Hemacandra, p. 43, line 19). Two main varieties of this metre are given by Hemacandra and the author of Kavidarpaṇa. They are Kuṁkuma and Karpūra. The former contains 27 and the latter 28 Mātrās in each of the two lines. In both, the Yati appears after the 15th Mātrā, so that the line is practically divided into two parts, one consisting of 15 Mātrās occurring before the Yati or the Caesura and the other containing 12 or 13 Mātrās according as it is Kuṁkuma or Karpūra and coming after it. Both CK. and PP. seem to treat this as a very well-known metre. CK. mentions it twice in connection with the two strophic metres *i.e.*, Ṣaṭpada (CK. 12) and Rāsākula (CK. 29) but does not define it independently anywhere. PP. also does not define it as an independent metre but gives its metrical formula while explaining the strophic Ṣaṭpada, of which Ullāla forms the concluding part. In the stanza (PP. 118) under question no varieties of the metre nor their names are mentioned. The definition given is that of the Karpūra which has 28 Mātrās in a line. The first part is made with three Caturmātras and one Trimātra, while the latter with a Ṣaṇmātra, a Caturmātra and a Trimātra, the two parts thus containing respectively 15 and 13 Mātrās. The pause after the 15th Mātrā is indeed not mentioned by PP. though it appears to be well established by the practice of the bards. It is, of course, explicitly mentioned by Hemacandra and the author of Kavidarpaṇa. The two allusions of CK. are similarly to the Karpūra and not to the Kuṁkuma. This fact perhaps shows that Karpūra was the most general type of the Ullāla and Kuṁkuma was merely a variation of it. Twenty-five varieties of the Karpūra are possible according as it contains from 8 to 56 *short* letters in each of its lines. The first of these containing 8 short letters and the rest long is called Bāha and the remaining 24 varieties which have other names are made by the addition of two short letters in succession in the place of one long letter which is dropped. Hema-

candra refers to these varieties as mentioned by some but does not consider them as very important and therefore neglects them.

12. A striking use of the term Ullāla = Ullālaka, however, is made in a stanza which defines the Kuṇḍalikā metre and which occurs in both CK. (31) and PP. (146) with slight but very significant changes. Kuṇḍalikā is a strophic metre and consists of a Dohā coupled with what is called an Ullāla but is, in fact, a Kāvya consisting of four lines, each containing 24 Mātrās. The actual words of the definition in CK. are :—

'Dohā cchandu ji paḍhama paḍhi kavvaha addha nirutta
'Tam Kuṇḍaliyā buha muṇahu Ullālai samjutta.'

The commentator of CK. considers this Ullāla to be a metre of four lines containing 24 Mātrās each. He remarks :—"Ullālakena Ṣaṇṇavatimātrāmayena samyuktam.' He, however, does not explain how the words "kavvaha addha nirutta' in the definition are to be interpreted. The three commentators of PP. explain the term 'ullālai samjutta' in the following manner :—(1) Sampurṇā Dohaiva prathamārdham, Kāvyacchandas sampūrnam parārdham padacatuṣṭayādadhikapādasya Ullālasañjnā—' [The complete Dohā (forms) the former half and the complete Kāvya (constitutes) the latter half; Ullāla is the name of the (two) pādas or lines which come after the (first) four lines].' (2) Ullālanam Ullālah, katipayavarṇānām parāvṛtya paṭhanam (Ullāla is springing up, *i.e.*, the pronunciation of a few letters after turning back *i.e.*, for second time). (3) Ullālah padāvṛttis (Ullāla is the repetition of words or letters). It will be observed that the first of these describes the *last two lines* of the metre only as the Ullāla but at the same time admits that the metre is made up of a Dohā and a Kāvya only. This would mean that the last two lines of a Kāvya are *here* called the Ullāla. The explanation is obviously unsatisfactory. The other two commentators on the other hand, do not take the word Ullāla in the sense of a metre of that name. According to them it means alliteration. Though this interpretation is very artificial, I think it is surely the most acceptable one. CK. uses the word Ullāla in a similar sense again, in the definition of Kuṇḍalinī (CK. 38) :—

Padhiūṇa paḍhama Gāhā purao paḍhiūṇa kavvapayajuyalam ।
Ullālaya samjuttam Kuṇḍalinī hoi suniruttam ॥

Even here the commentator takes the word to mean a metre of 96 Mātrās; but this is not convincing. The word 'Kavvapayajuyalam' makes it very doubtful. 'Ullālayasamjutta' is merely an adjective of 'Kavvapayajuyala' which latter is to be actually 'recited' and hence forms part of the Kuṇḍalinī. 'Ullāla' thus is something which belongs to Kavva and cannot therefore be regarded as the name of a

metre. 'Kavvapayajuyala' is to be taken in the sense of 'Kavvapayajuyala-juyala' *i. e.*, a pair of the pairs of the lines of 'Kāvya' as indeed is admitted by the commentator in the following words 'Kāvyasya Ṣaṭpadāpekṣaya padacatuṣṭayasyāpi padayugalasajñā'. The commentator must be understood either to take the word "Kavva" in the sense of an ordinary 'poem' or the words 'Kavva' and 'Ullāla' as synonyms. His explanation, however, in either case is certainly not correct. No such Ullāla is known to exist nor is the Kāvya called Ullāla by any writer on Metrics. The fact seems to be that the original writer of the stanzas in question has employed the word Ullāla rather loosely in the sense of alliteration. Ratnaśekhara borrowed the stanzas without any variation. PP. also borrowed it from the same source as CK., making a slight but significant change by the insertion of Piṅgala's name into it. The original writer of the stanza might have been an Apabhraṁśa poet, perhaps Arjuna or Gosala. The other two stanzas (CK. 12, 29) where the ordinary Ullāla is mentioned are from Gosala's pen. But we shall discuss this point later on.

13. The remaining three Dvipadīs *i. e.* Śikṣā, Mālā and Khañjā are defined only in PP.; CK. does not mention them. None of these three, however, can be strictly called a Mātrāvṛtta. In a pure Mātrāvṛtta, there are no restrictions regarding the quantity or number of the letters employed, the only thing required being the separateness of the various Mātrāgaṇas. This separateness is to be maintained by not allowing a long letter to represent the two Mātrās belonging to two different Mātrāgaṇas. This means that the last Mātrā of an earlier Gaṇa must not be combined with the first Mātrā of a succeeding Gaṇa into a long letter, for then the two Gaṇas cannot be felt or pronounced separately. In short, a long letter must not be employed at the junction of two Mātrāgaṇas. This is the only negative rule with regard to the letters which requires to be observed in a pure Mātrāvṛtta. Otherwise any number and any kind of letters *i. e.*, short or long can be used to form the individual Mātrāgaṇas.

14. Considered from this point of view, all the three metres are not pure Mātrāvṛttas since there are many restrictions in them with regard to the letters which are to be employed for forming the different Mātrāgaṇas. Thus in Śikṣā (PP. 161) the first line is to be made with six Dvijagaṇas (*i.e.*, a Caturmātra Gaṇa where four short letters are used to represent the four Mātrās) followed by Jagaṇa (1S1), while the second, with seven Dvijagaṇas followed by a Jagaṇa. In Mālā (PP. 164), the first line is made with nine Dvijagaṇas followed by Ragaṇa (S1S) and a Karṇa (*i. e.*, a Caturmātra in which the four Mātrās are represented by two long letters) at the end and

the second line is the second line of the ordinary Gāthā metre. Strictly speaking both these are Viṣama Vṛttas and for the sake of mere convenience are discussed here. Khañjā (PP. 158) on the other hand is a Samavṛtta and each of its two lines contains nine Dvijagaṇas followed by a Ragaṇa.

15. Coming next to the Catuṣpadīs, we shall first take up those among them that are pure Mātrāvṛttas as described above. Only six such metres are given by PP. and CK. together. Four of these are given by CK. alone one by PP. alone and only one is common. The first and the shortest among these is the *Vijayaka* (CK. 19). Each of its Pādas is made up of only 8 Mātrās. No special Mātrāgaṇas are prescribed. The second is *Ekāvali* (CK. 47); it has 10 Mātrās in each of its four Pādas and they are to be made up by using two Pañcamātra Ganas. A long letter, therefore, must not be used to represent the 5th and the 6th Mātrās together in this metre. It is the same as the Kāminīmohana or Madanāvatāra but only half of it in length. The 3rd is *Laghucatuṣpadī* (CK. 40). Its line contains 15 Mātrās, the last five of which are to be represented by a Pañcamatra Gana. No special Ganas are prescribed for the first ten Mātrās. According to the rule explained above, this means that the *tenth* and the *eleventh* Mātrās must not be combined into a long letter, and there are no restrictions regarding the use of short or long letters for the first ten Mātras. The fourth is the *Pādākulaka* (PP. 129). Its Pāda contains 16 Mātrās without any restrictions concerning either the Mātrāgaṇas or the letters. The fifth is the *Dvipadī* (CK. 35; PP. 152); its line contains 28 Mātrās arranged in the Ganas of 6, 4, 4, 4, 4, 4, and 2 Mātrās or according to PP. of 6, 4, 4, 4, 4 and 6 Mātrās respectively. It appears that the practice of the bards had sanctioned that the last two Mātras must be represented by a long letter and this is actually mentioned in PP. 154 though no trace of it is found in the earlier definition (*i. e.* v. 152) and also in that of CK. That is why the metre is mentioned here by me. The sixth and the longest metre of this type is the *Catuṣpadī* (CK. 37). Its line contains 30 Mātrās made up by the employment of seven Caturmātras and one Dvimātra. This is different from another Catuṣpadī (PP. 97) which is of the same length but whose lines are really made up of three shorter lines, and which, therefore, is treated under the Dvādaśapadīs. Even here the commentator says that the last Dvimātra must consist of a long letter (Dvikalam gururūpam kriyate) but the text itself does not say anything like it.

16. Although the pure Mātrāvṛttas allow a greater freedom to the poets in their composition when compared with the Varṇa Vṛttas, yet they lack in the charming rhythm which is produced by

the introduction of long and short letters in particular places or at definite intervals. The Varṇavṛttas which afford such rhythm are nevertheless very exacting and did not find any great favour with the Prākṛta poets whose Muse sought an unfettered expression of thought and did not like to be dictated to, though of course it produced its own peculiar rhythm. The Prākṛta poets generally adopted the Mātrāvṛttas for their purpose and produced their individual rhythm in their own peculiar way. When such a rhythm was generally employed by well known poets of great merit owing to its attractiveness, it was usually imitated by others and in course of time came to be regarded as compulsory. Thus it is why the employment of short or long letters in particular places of a Mātrā Vṛtta to represent a particular Mātrāgaṇa is not only recommended but prescribed by writers on Prakṛta Metre in their definitions. All such rules have naturally to be regarded as based upon the general practice of the Prakṛta poets.

17. It is easy to understand how on account of this tendency to have a fixed rhythm, almost all Mātrāvṛttas came to have a definite kind of letters at definite places in them. Sixteen such metres of four lines are defined by CK. and PP. together. The shortest among them is the *Madhubhāra* (PP. 175) with 8 Mātrās in each line. Out of the two Caturmātras which are to be employed in a line of this metre, the second must always be a Payodhara (1S1) with its two middle Mātrās represented by a long letter. In reality Madhubhāra is a half Pajjhaṭikā *i. e.* is equal to two lines of it (see below). The second metre of this kind is the *Dīpaka* (PP. 181). Its line contains 10 Mātrās like that of the Ekāvalī (see para. 15) but they are made up by employing a Caturmatra, a Pañcamatra and a short letter at the end. As a matter of fact Dīpaka and Ekāvalī seem to be the same and are equal to a half Madanāvatāra, which latter is a well-known and popular Apabhraṁśa metre commonly employed in narrative poetry. It is not actually defined by PP., but CK. defines it under the name of Kāminīmohana (CK. 10) and mentions it while defining the strophic metres Candrāyana and Candrāyanī. The next is the *Ābhīra* metre (PP. 177) with 11 Mātrās in its line, the last four of which must by represented by a Payodhara (1S1). *Hākali* (PP.172) comes next with its line of 14 Mātrās made up by employing three Caturmātras and a long letter at the end. The three Caturmātras may be of any type except those that are made with two long letters or with a long letter in the middle. The remaining three varieties which can therefore be employed are those that are formed with a long letter at the beginning or at the end and those that contain all short letters. The fifth, sixth, seventh, eighth and ninth metres of this kind are *Pajjhaṭikā* (CK. 36; PP.125)

Mālati (CK.49), *Aḍilā* (CK.41; PP.127) *Maḍilā* (CK.41) and *Siṁhāvaloka* (PP.183) each containing 16 Mātrās in its line. Of these Pajjhaṭikā is only a doubled Madhubhāra as we saw above. As in Madhubhāra, even here the last Caturmātra must be a Payodhara (1S1); the other three may be of any type. The 16 Mātrās in the line of Mālati must be made up by using Trimātra or Pañcamātra Gaṇas only, each of which must naturally contain at least one short letter. Thus there must be at least four short letters in each line. This metre at first looks like a pure Mātrāvṛtta but it is really not so since it contains a restriction regarding the least number of short letters which it must contain in its line. In the case of Aḍilā and Maḍilā which too contain 16 Mātrās in their lines made up of four Caturmātrās like Pajjhaṭikā, there are similar restrictions. None of the Caturmātrās must be a Payodhara (1S1) and the last two Mātrās of the last Gaṇa must always be represented by two short letters. When all the lines have a common rhyme, this metre is called Aḍilā but when the third and the fourth lines have a different rhyme, it is called Maḍilā. In Siṁhāvaloka, on the other hand, the four Caturmātrās in each line must be either of the Vipra (1111) or of the Sagana (S11) type. This means that in a line, not more than four long letters must be employed. The tenth metre of this class is the *Plavaṅgama* (PP.186-188) with its line containing 21 Mātrās which are to be made up by using at the beginning, a Ṣaṇmātra commencing with a long letter, followed by two Ṣanmātras of any type and a Trimātra with a long letter at the end. Thus the important condition in this metre apart from the separateness of the Mātrāgaṇas, is that there must be a long letter both at the beginning and at the end, the latter being preceded by a short letter. The eleventh is *Ābhāṇaka* (CK. 17) which also has 21 Mātrās in a line like the Plavaṅgama but they are made up by employing any kind of Mātrāgaṇas except the Pañcamātra Gaṇas. The last Mātrā (last three Mātrās according to the commentator) again must be represented by a short letter. The condition regarding the avoidance of Pañcamātrika Gaṇa seems to refer in particular to the Ragaṇa type which consists of two long letters with a short one between them (S1S), since this Gaṇa alone is studiously avoided in the example. The twelfth is *Hīra* (PP.199) with 23 Mātrās in a line. These are made up by using three Ṣaṇmātras followed by a Pañcamātra of the Ragaṇa type (S1S) at the end. Each of the three Ṣaṇmātras again must be made up of a long letter followed by four short ones (S1111). Thus there must be five long letters and thirteen short ones in every line. The thirteenth is *Kāvya* (PP.109, CK. 31,38) variously called Rolā (PP.91), Roḍaka (CK.13), Vastu (CK.13, PP.115) and Rāsākula (Com. on CK.13). It would seem as if PP. regarded

Rolā and Kāvya as two distinct metres but on a closer observation it will be found that this is not a fact. According to PP.91, a line of Rolā must contain at least 2 short letters (since it may contain not more than 11 long letters) and no special Mātrāgaṇas are prescribed for it while in a Kāvya (PP.109), the particular Mātrāgaṇas are stated. They are 6,4,4,4 and 6 *i.e.* two Ṣaṇmātras at either end with three Caturmātras in the middle. The second of these three Caturmātras must be either a Jagaṇa (1S1) or a Vipragaṇa (1111). Thus ultimately even like Rolā, a line of Kāvya must contain at least two short letters (namely those of the Jagaṇa in the third place). Both again may contain all short letters. Hence but for the Mātrāgaṇas the two metres seem to be wholly identical. As a matter of fact CK.12,13 defines Roḍaka with almost the same Mātrāgaṇas but without the restrictions concerning the third Gaṇa and seems to regard Kāvya as the same as Roḍaka in v. 31 and v. 38. The fourteenth is *Gaganāṅka* (PP.149) with its line of 25 Mātrās which however, must be represented by 20 letters. Of these naturally 5 will be long and 15 short. The first Gaṇa must be a Caturmātra [which means that a long letter must not be used to represent the 4th and the 5th Mātrā as seen above. This rule is not followed in the third line of the illustration (PP.151) according to the reading adopted in the text, but the reading indicated in the footnote is quite all right] and the last letter must be long and must be preceded by a short one. The fifteenth is *Gīta* (CK. 18) also called *Harigīta* (PP.191). Its line contains 28 Mātrās. The first, third, fourth and fifth Gaṇas must be Pañcamātras of any kind; the second must be a Ṣaṇmātrā and the last two Mātrās of every line must be represented by a long letter. The peculiarity of this metre is that the 5th, 12th 19th and 26th Mātrās in each line must be represented by a short letter while the remaining Mātrās may be represented by the use of short or long letters according to convenience. This is secured by the restrictions laid down above. The metre is a song metre which is sung in the Dīpacandī Tāla where the beat of the drum occurs after every seven Mātrās since the Tāla consists of 7 Mātrās. In one line, therefore, we shall get four strokes and between any two strokes we shall have seven Mātrās. These seven Mātrās may be represented in any manner but it is always necessary to employ at least one short letter. The most convenient place for this short letter is the third Mātrā after the beat or the stroke. And since the first beat in this metre occurs on the third Mātrā, the first short letter will naturally occur at the 5th Mātrā. To preserve harmony, it must occur at regular intervals which is naturally of seven Mātrās. This is why there must be at least four short letters in every line, separated from each other by a distance of seven Mātrās. The last

and the sixteenth metre of the restricted type of the Catuṣpadīs is the *Daṇḍaka* (CK.30). Its line contains 32 Mātrās made up by employing 8 Caturmātras. No special restrictions are laid down in the text but in practice there appear to be some restrictions; for the Daṇḍaka is conceived as a doubled Pajjhaṭikā or a quadrupled Madhubhāra. The even Caturmātras (*i. e.*, the 2nd, 4th &c.,) are for this reason generally of the Payodhara type (1S1).

18. All these Catuṣpadī metres of the mixed and pure type have another kind of rhythm in addition to the one which is produced by the introduction of short and long letters at certain places. This second rhythm is produced in a peculiar way by the mere avoidance of a long letter representing two successive Mātrās at a particular place in a line. Thus in a line of the Madhubhāra metre it will be observed that the 2nd and the 3rd Mātrās are never combined into a long letter; in that of a Pajjhaṭikā, the 2nd and the 3rd as also the 10th and the 11th Mātrās cannot be so combined. This rule though not expressly mentioned in most cases is nevertheless invariably observed and is indicative of the fact that these metres were sung to the accompaniment of a sounding hand-drum which was beaten at regular intervals. Such intervals can be marked by Mātrās alone and not by letters and since a beat of the drum cannot be made to accompany the second of the two Mātrās represented by a long letter, it is clear that the Mātrās on which the beats of the drum occur must begin a new letter whether short or long and cannot be combined into a long letter along with those Mātrās which precede them immediately. Usually the interval between the two beats of the drum is of 8 Mātrās as most metres are sung in the Dhumāli Tāla which is the commonest of all Tālas and consists of 8 Mātrās or their multiples. There are some metres, however, which are sung in other Tālas which consist of 5, 6 or 7 Mātrās and are called Jhampā, Dādarā and Dīpacandī respectively. Then the interval between the two beats will naturally be of 5, 6, or 7 Mātrās. The first beat may occur on the 1st or the 3rd Mātrā according to the practice of the singer though in certain cases a clear preference is shown for the 3rd, by the position of the Yati and the Yamaka. If after the last stroke or beat, a sufficient number of Mātrās required for the particular Tāla are not found in the song itself, so as to bring the first beat in the next line at its proper time and thus to ensure the continued narration and music, then a pause of the necessary number of Mātrās must be introduced at the end of every line since otherwise the whole Tāla will be disturbed. A concrete example will make this point clear. The Hākali metre is sung in the Tāla of 8 Mātrās. The first beat occurs on the first Mātrā; the next naturally on the 9th. A line contains only 14 Mātrās.

Hence the third beat (which is the first of the next line and comes on its 1st Mātrā) will occur after an interval of 6 Mātrās instead of 8 and the whole scheme will be disturbed. In order to avoid this, a pause of 2 Mātrās must be introduced at the end of each line, thus to ensure the required interval of 8 Mātrās.

19. It will thus be seen, that in song metres there will be required another kind of Gaṇas, in addition to the ordinary Mātrāgaṇas. These additional Gaṇas may be called Tālagaṇas since they are requird for the preservation of the Tāla. A Tālagaṇa consists of as many Mātrās as occur between the two beats of the drum. The separateness of these Tālagaṇas has to be maintained like that of the ordinary Mātrāgaṇas. Thus the last Mātrā of an earlier Tālagaṇa cannot be combined into a long letter along with the first Mātrā of a later one, or in other words, as said above, the Mātrās on which the beat occurs *i. e.*, with which a new Tālagaṇa begins, must begin a new letter whether short or long. In short, a long letter must be avoided at the junction of two Tālagaṇas. The Mātrās within the Tālagaṇa may be made up in any way but when a Tālagaṇa consists of an odd number of Mātrās (*e. g.*, 5 or 7) it must contain at least one short letter and the position of this letter is generally the 3rd Mātrā (sometimes also the 5th or the 7th) of the Tālagaṇa (See above, the remarks on the Gīta or Harigīta). Ekāvali (CK. 47), Dīpaka (PP. 181) and Jhullaṇā (PP. 156) are all sung in the Tāla of 5 Mātrās ; in the first two the 5th Mātrā of the Tālagaṇa which consists of 5 Mātrās, is represented by a short letter while in the last, the short letter stands in the place of the 3rd Matrā.

20. Among the six pure Catuṣpadīs, Vijayaka, Laghucatuṣpadī, Pādākula and Catuṣpadī are sung in the Tāla of 8 Mātrās, the first beat being on the first Mātrā. There is a pause of 1 Mātrā in Laghucatuṣpadī and of 2 Mātrās in Catuṣpadī at the end of each line. Ekāvali like the Madanāvatāra is sung in the Tāla of 5 (or 10) Mātrās, the first beat being on the 3rd Mātrā or even on the 1st ; but the Tāla of Dvipadī is doubtful. Coming next to the mixed Catuṣpadī metres, Madhubhāra, Ābhīra, Hākali, Pajjhaṭikā, Aḍilā, Maḍilā, Mālati, Siṁhāvaloka, Ābhāṇaka, Plavaṅgama, Roḍaka or Kāvya and Daṇḍaka are all sung in the Tāla of 8 Mātrās, the first beat occurring on the 1st Mātrā except in the case of Madhubhāra, Pajjhaṭikā, Siṁhāvaloka and Daṇḍaka, where the tendency is evidently to have it on the 3rd. In the case of Ābhīra, Hākali, Ābhāṇaka and Plavaṅgama, there will be a pause of 1, 2, 3 and 3 Mātrās respectively at the end of a line. Dīpaka like Ekāvali is sung in the Tāla of 5 (or 10) Mātrās, Hīra in that of 6 Mātrās and Gīta or Harigīta in that of 7 Mātrās. The Tāla of Gaganāṅka

again is doubtful like that of the Dvipadī. In Hīra, the first beat is on the first Mātrā while in Ekāvalī, Dīpaka and Gīta it appears to be on the third.

21. Among the Samavṛttas defined by CK. and PP. there is only one with six lines and it is *Rasikā* (PP. 86). Its line contains 11 Mātrās all represented by short letters. Thus we have 4 Dvipadīs, 22 Catuṣpadīs and 1 Ṣaṭpadī among the Samavṛttas.

22. Before going to the Ardhasamavṛttas, it will be convenient here to take up the only two metres which are formed by a mixture of Dohā and Gāthā, and which, therefore, cannot be properly called either Sama or Ardhasama Vṛttas. Both these are defined by CK. alone; PP. does not seem to know them. The first is *Verālu* (CK. 33), the first three lines of which are those of a regular Dohā and the last one is the last line of the Gāthā containing 15 Mātrās. The second is *Cuḍāmaṇi* (CK. 48); its first half is equivalent to the first half of a Dohā while the second is the same as the latter half of a Gāthā. Both these are striking combinations and show the great popularity of the Gāthā and the Dohā among the Prākṛta poets. Gāthā is rightly the Prākṛta and Dohā the Apabhraṁśa metre but their happy combination seems to have been the work of those Apabhraṁśa poets who were well-versed in Prākṛta literature and therefore could not altogether forget their favourite Gāthā. I naturally mean that they were probably invented by those Jain Monk-Pandits who in later centuries wrote their poems in the Apabhraṁśa language.

23. There are 19 Ardhasama Vṛttas defined by CK. and PP. together. Six of these are Catuṣpadīs, four are Ṣaṭpadīs and nine are Dvādaśapadīs. The most important among the six Catuṣpadīs is the *Dohā* (CK. 21, PP. 78) which is the earliest and the most popular among the Apabhraṁśa metres after Mātrā. The metre is also found in vernacular poetry particularly in Hindi. Its odd lines contain 13 Mātrās while the even ones contain only 11. When 5 Mātrās more are added to the even lines of the Dohā it is called *Culikā* (CK. 26, PP. 167) and when 10 more are added to these same lines it becomes *Upaculika* (CK. 27). In the same manner, when 2 more Mātrās are added to its *odd* lines, the Dohā is called *Udgāthaka* (is it Uddohaka? CK. 28;). Hemacandra (p. 42a, line 3) calls it Madanavilāsa, while Kavidarpaṇa says it is Sandohaka. An inverted Dohā is called *Soraṭṭha* (CK. 25, PP. 170); its odd lines contain only 11 Mātrās while the even lines have 13. The additional feature of this metre is that its 1st and 3rd lines also are rhymed like the 2nd and the 4th. The name appears to be significant as it probably indicates that this metre *i. e.*, inverted Dohā with the double Yamaka originated in Saurāṣṭra and was very popular with its bards. The

sixth metre of this type is *Besara* (CK. 20). It is, however, slightly different from the rest. In the case of the first five metres, *i. e.* the Dohā and its four derivatives, the 1st and the 3rd as also the 2nd and the 4th lines are similar but in the Besara metre the 1st and the 2nd lines are similar and so are the 3rd and the 4th. They are also rhymed. The first two lines contain 16 Mātrās each while the last two contain 15 each.

24. The next main division of the Ardhasama metres is the Ṣaṭpadī. Under this head I intend to discuss four metres namely *Ghattā* (CK. 43, PP. 99), *Ghattānanda* (PP. 102), *Jhullaṇā* (PP. 156) and *Caubolā* (pp. 131). All of them are treated by PP. as metres of two lines except the Caubolā which is regarded by him as a metre of four lines. CK. on the other hand treats the Ghattā as a metre of four lines. It appears that opinion was divided as to whether the Ghattā should be regarded as a Dvipadī or a Catuṣpadī or a Ṣaṭpadī. Ghattā indeed is a general name given to either a Dvipadī or a Catuṣpadī or a Ṣaṭpadī according to Hemacandra, p. 43a, line 14 ff.; but whether the particular type of Ghattā mentioned by CK. and PP. is to be treated as a Dvipadī or otherwise is the question. PP. defines this variety as a metre of two lines, each containing 31 Mātrās made up by employing 7 Caturmātras followed by three Mātrās more, all represented by short letters. In each line there is the Yati first after 10 Mātrās and then after 8 Mātrās. The first part of the 10 Mātrās is rhymed with the second part of 8 Mātrās in both lines, the third part of the first being at the same time rhymed with the third part of the other line. CK. on the other hand describes it as a metre of four lines, of which the first and the third contain 18 Mātrās each; while the second and the fourth have only 13 each. He does not mention the Yati after the 10th Mātrā in the odd lines though he seems to mean it, as is obvious from the rhyme of this part with the remaining one of 8 Mātrās which he employs like Piṅgala. As a matter of fact, PP. also does not mention the Yamaka but he actually uses it both in the definition and in the illustration (PP. 99, 101). Hemacandra mentions this same variety under the Dvipadīs (p. 44a, line 5) but calls it Chhaḍḍaṇikā. He too like PP. mentions the Yati but not the Yamaka which, however, he does not employ as PP. does. Kavidarpaṇa, on the other hand, gives six varieties of Ghattā, each of which contains six lines. He thus treats it as a Ṣaṭpadī. The variety in question also is mentioned among these six. Its two halves are made up of three lines each which respectively contain 10, 8 and 13 Mātrās. The 1st and the 2nd, the 4th and the 5th and the 3rd and the 6th are rhymed. Looking to the position of the Yati and the rhyme, I am personally inclined to follow Kavidarpaṇa and hence I have put the Ghattā

under the Ṣaṭpadīs. The other five varieties of Ghattā according to the Kavidarpaṇa are those whose halves consist of three lines containing respectively, 12, 8, 13; 8, 8, 11; 10, 8, 11; 12, 8, 11; and 12, 8, 12 Mātrās. The commentator of Kavidarpaṇa says that these six are merely illustrative; there are many more varieties of the Ghattā. Ghattānanda is regarded by me as a Ṣaṭpadī for similar reasons. Each of its two halves is made up of three lines containing respectively, 11, 7 and 13 Mātrās. Caubolā, which is regarded by PP. as a Catuṣpadī metre, must also be considered as a Ṣaṭpadī having two halves each containing three lines of 8, 8 and 14 Mātrās on the same principle. Both Ghattānanda and Caubolā come under the Ṣaṭpadī Ghattā according to the scheme of the commentator of Kavidarpaṇa. (Evam Saptadaśakalādyaih Saptakalāntaih pādaih tulyaih atulyaih tulyātulyaih vā tribhis tribhis baddhārdhadvayā anekadhā Ghattā). Also cf. Hemacandra, p. 38a, line 16. Jhullaṇā, which is treated by PP. as a Dvipadī must similarly be considered as a Ṣaṭpadī. The three lines of each of its two halves contain 10, 10 and 17 Mātrās respectively and thus it also comes under the Ṣaṭpadī Ghattā mentioned above. It will be observed that in all the four cases, the peculiar rhyme of a Ṣaṭpadī is employed (*i. e.*, the rhyme of 1st and 2nd, 3rd and 4th and 5th and 6th Pādas; cf. Hemacandra, p. 38, b, line 9 ff.).

25. All these four Ṣaṭpadīs are song metres and are sung in the Dhumālī Tāla of 8 Mātrās. No special Mātrāgaṇas are laid down except in the case of the Ghattā and Ghattānanda. But even there they appear to be neglected on the whole, the greater importance being attached to the Tālagaṇas (see above para 19) as they are song metres. The first beat in the case of the Ghattā occurs on the 3rd Mātrā as in Pajjhaṭikā, the 2nd on the 1st Mātrā of the second line, the 3rd on the 1st Mātrā of the third line and the 4th on the 9th Mātrā of the same line. The next beat will come again on the 3rd Mātrā of the 1st line of the second half securing in this manner a distance of 8 Mātrās between the last beat and this one, taking into account the pause of one Mātrā at the end of each half, which is necessary for this very purpose. It is in this manner that there always occurs the beat after 8 Mātrās and the narrative as also the music are not interrupted. This Ghatta is usually employed at the end or even at the beginning of the Kaḍavas in the Apabhraṁśa poems for the sake of variety and also for giving some breathing time to the singer (cf. Hemacandra, p. 38a, line 13). The Kaḍavas are generally composed in the Pajjhaṭikā metre which is musically similar to Ghattā and hence the music is not disturbed though variety is at the same time secured. That the first beat in Pajjhaṭikā usually occurred on the 3rd Mātrā of each line (see above

para 20) is further evident from the rule regarding the formation of its line found in some books like Kavidarpaṇa and Hemacandra, p. 26b, line 6 ff. According to this rule which is also mentioned by the commentator of CK. 36 (Atra pade pade Dvitīyacaturthacatuhkale eva jagaṇo bhavati nānyatreti āmnāyah). Out of the four Caturmātras in each line the 1st and the 3rd *must* not be a Jagaṇa (ISI). This means that the 2nd and the 3rd Mātrās as also the 10th and the 11th Mātrās must not be combined together into a long letter. For if they are so combined, the beat on the 3rd and the 11th Mātrās will be disturbed as it cannot accompany the *second* of the two Mātrās represented by a long letter as said above. Caubolā (8, 8, 14X 2) is sung in the same Tāla as the Ghattā but its 1st beat occurs on the 1st Mātrā instead of the 3rd. The 2nd beat occurs on the 1st Mātrā of the second line while the 3rd and the 4th occur on the 1st and the 9th Mātrās of the third line. At the end of the 3rd and the 6th lines, *i. e.* at the end of each half there is a pause of 2 Mātrās which would secure the usual distance of 8 Mātrās between the 4th beat of the preceding half and the initial beat of the succeeding half. The rhythm of Ghattānanda (11, 7, 13 X 2) seems to be irregular. In Jhullaṇā which is sung in the Jhampā Tāla, the distance between the two strokes or beats is of 5 (or 10) Mātrās and the first beat occurs on the 1st Mātrā. At the end of each half i. e. at the end of 3rd and 6th lines, there occurs a pause of three Mātrās to fill up the gap. This metre has descended down to Marathi where it is called Jhampā. It is employed in older Marathi dramas to express an outburst of feeling in general. It is most suited to hasty and angry gestures and quick movements of the body.

26. I have classified the next nine metres as the Dvādaśa padīs. They are treated as the Catuṣpadī Samavṛttas both by CK. and PP. ; but the consideration of rhyme and Yati within the line has led me to the conclusion, as in the case of Ghattā, that each single line of all these metres is actually made up of *three shorter ones*. They all appear like a doubled Ghattā and are to be sung in exactly the same manner. The first beat occurs in all of them on the 3rd Mātrā and the next beats occur regularly after an interval of 8 Mātrās, taking the help of the pause at the end of every line, wherever necessary. The first among these nine metres is the *Catuṣpadī* (PP. 97) also called *Hakkā* (CK. 45). Each of its four Pādas is made up of three shorter lines containing 10, 8 and 12 Mātrās respectively. There is a pause of 2 Mātrās at the end of each Pāda. The second is *Marahaṭṭā* (PP. 208) ; each of its four Pādas consists of three lines containing 10, 8 and 11 Mātrās. There is a pause of 3 Mātrās at the end of a Pāda. The next six metres

are very similar to each other. The difference is only in very minor points and one is led to believe that they are but the different names of the same metre. The Pādas of all these six metres are made up of three short lines containing 10, 8, and 14 Mātrās in order. There is no necessity of a pause at the end of a Pāda in them. The first beat, of course, occurs on the 3rd Mātrā as in the case of the other Dvādaśapadīs as said above. The differences between them are as follows:—In *Padmāvatī* (CK. 50; PP. 144) there is no rhyme within the Pāda but the avoidance of Jagaṇa among the 8 Caturmātras to be employed in each Pāda is specially emphasised. This Jagaṇa is of course impossible for the same reasons for which it is to be avoided in the Pajjhaṭikā (see above para 25). In *Daṇḍakala* (PP. 179) the Yati within the line is not mentioned but is surely intended as is evident from the Yamaka at that place. Both Yamaka and Yati are mentioned within the line in the case of *Tribhaṅgī* (PP. 194) as well as *Durmilā* (PP. 196). In *Jalaharaṇa* (PP. 202) the Yati is mentioned but not the Yamaka; while in the *Līlāvatī* (PP. 189) neither is mentioned though the Yati is very obviously intended. Further in Jalaharaṇa, all letters must be short while in Tribhaṅgī, the avoidance of Jagaṇa is also mentioned. An additional feature of this last metre is that its Pāda appears to be made up of *four* short lines of 10, 8, 8 and 6 Mātrās instead of the usual three as is clear from an additional rhyme. The last and the ninth metre of this kind is the *Madanagṛha* (PP. 205). It is the same as any one of the above-mentioned six, but with an addition of further 8 Mātrās at the end of each Pāda. It is as a matter of fact a Ṣoḍaśapadī like Tribhaṅgī. It is this metre and in particular the additional Pāda which at once reveals the fact that it was employed for a dance with Tiparis. When the metre is sung we feel as if we see before us the sudden turns which the dancers take after every four beats, here strokes of the Tiparis. The other Dvādaśapadīs too make a strong impression that they also were used for a dance with Tiparis.

27. The next great division is the strophic metres. PP. and CK. together mention seven such metres. Strophic metres are not peculiar to Prākṛta poetry. They are abundantly found in Vedic Literature and in a limited sense also in Classical Sanskrit. In Vedic Literature two stanzas in different metres are often combined to form a Pragātha while in classical Sanskrit two or more stanzas *in the same metre* are combined and are then called Yugmaka, Kulaka, Viśeṣaka &c. In Prākṛta and Apabhraṁśa, particularly in the latter, again they are found in abundance. There is, however, some vital difference between the Vedic and the Prākṛta strophes. In a Vedic strophe, two or three stanzas form only a metrical and

not necessarily a syntactical unit, whereas in Prākṛta they often form a syntactical unit as well. This means that a sentence is not completed in the first stanza but is often made to run into the second. The stanzas thus show a closer connection with each other and indicate that their origin was due as much to the necessity of finishing a sentence or a topic (cf. J.B.B.RAS. 1929, p. 61, v. 41) as to the idea of variety and ornamentation; and this is quite in keeping with the all-round freedom enjoyed by the writers of popular Prākṛta poetry.

28. All these seven strophic metres are made by combining together any two of the most popular among the Apabhraṁśa metres namely Ullāla, Dohā, Gāthā, Ābhāṇaka, Kāvya, Mātrā, and Kaminī-mohana or Madanāvatāra. We have noticed all these except Mātrā and Madanāvatāra. *Mātrā* seems to be a very old Apabhraṁśa metre since it was known to Virahāṁka (see Vṛttajātisamuccaya, JBBRAS. 1929,p.87) who describes four different varieties of it, *i. e.*, Karahī, Mādanikā, Cārunetrī and Rāhusenī. The uneven Pādas (for it is an Ardhasama metre and contains five Pādas) of these respectively contain 13,14,15 and 16 Mātrās, the even ones having 11,12,13 and 14. Hemacandra's normal Mātrā is different. It contains 16 Mātrās in the odd lines and 12 Mātrās in the even ones. He gives five more varieties derived from Mātrā but does not reckon them as the divisions of it. They are Mattabālikā, Mattamadhukarī Mattavilāsinī, Mattakariṇī and Bahurūpā. The uneven lines of these contain 14,16 or 17 Mātrās, while the even ones have either 11,12 or 13 Mātrās (cf. p. 36a, line 9 ff). Piṅgala discusses this metre under Raḍḍā, and gives seven varieties of it. They are Karahī (13,11,13, 11,13), Nandā (14,11,14,11,14), Mohinī (19,11,19,11,19), Cārusenī (15,11,15,11,15), Bhadrā (15,12,15,12,15), Rājasenā (15,12,15,11,15), and Tālaṅkinī (16,12,16,11,16). CK. also does not define the metre independently but only in connection with the strophic metre called Vastu or Raḍḍā and there too gives only one variety (*i.e.*, Piṅgala's Cārusenī containing 15,11,15,11 and 15 Mātrās in its five Pādas). It is again curious to note how CK. calls this metre by the name Rāḍhaka and not Mātrā. From this great divergence of views regarding the formation of its lines, the metre appears to have enjoyed very great freedom. In ancient times it was probably a popular metre of the Apabhraṁśa poets but in course of time seems to have been displaced by other metres like Dohā. Virahāṅka knows indeed the Dohā as an Apabhraṁśa metre since he composes its definition (IV.27) in that language but does not notice any varieties of it. When Pajjhaṭikā and Dohā came to the forefront with the development of Narrative poetry, the Mātrā, which is suited only to Lyrics, probably dwindled into insignificance owing to its five lines

which are a source of great inconvenience. The next metre which is not noticed so far but which is employed for a strophe is the Madanāvatāra or Kāminīmohana as CK. calls it. It is a metre of four lines each containing 20 Mātrās made up by the employment of four Pañcamātra Gaṇas. These Pañcamātra Gaṇas may be of any type but according to CK. 10 they should be of the Ragaṇa type (SIS). Really speaking, all the so-called Varṇavṛttas which CK. 9–11 describe are of this type. For the Madanāvatāra, cf. Hemacandra, p. 33b, line 2 ff. and Gāthālakṣaṇa (Annals B.O.R.I. Vol. 14, p.27) v. 78. In the latter place it is also called Candrānanā.

29. To come back to the strophic metres, a Dohā combined with a Kāvya (see para 17) gives rise to the *Kuṇḍalika* (CK. 31, PP. 146) while a Gāthā and a Kāvya are combined to form a *Kuṇḍalinī* (CK. 38). Similarly a Dohā combined with a Kāminīmohana or Madanāvatāra is called *Candrāyana* (CK. 32) while a Gāthā combined with the same metre gives rise to *Candrāyanī* (CK. 39). It is to be noted that a Dohā gives a masculine while the Gāthā a feminine name to the same strophe. An Ābhāṇaka (CK.17) or a Plavaṅgama (PP. 186) *i.e.*, a metre of four lines each containing 21 Mātrās (with a Yati after the 11th Mātrā, which seems to be intended) when coupled with an Ullāla becomes the *Rāsākula* (CK.29) while a Kāvya followed by the same Ullāla is called the *Saṭpada* (CK. 12; PP. 105). Lastly the *Vastu* or *Raḍḍā* is formed by the combination of a Mātrā of any kind according to Hemacandra (p. 36 b, line 15 ff.) with a Dohā or its derivatives. Virahāṅka and PP. obviously agree with this (133-143) but CK. 34 mentions only one kind of Mātrā for this purpose and that too without mentioning the name Mātrā.

30. Having thus examined the 55 Apabhraṁśa metres described by CK. and PP. together we shall now proceed to examine briefly the question of CK.'s authorship and its peculiar relationship with PP. In connection with the former, it is worthy of note that CK. consists of two parts written in an entirely different style and language. The first part *i.e.*, vv. 5-50 is written in the Apabhraṁśa language and in a rather loose and popular style which is characterised by ornamental adjectives and words like 'Nirutta', 'Tha', 'Buhayaṇa', Jāṇa', 'Muṇa', 'Jampa', 'Payampa' and others. In 17 of these 46 stanzas, the names of older writers are mentioned; thus Arjuna or Alhu as he was popularly called according to the commentator, is mentioned in 9 stanzas (10, 11, 15, 19, 27, 30, 34, 35 and 41), Gosala or Gulhu in 6 (6, 12, 14, 18, 26 and 29) and Piṅgala or the lord of the Nāgas in 2 (4 and 45). There are again two allusions (vv. 12 and 29) to the vain arrogance and ignorance of Sanskṛta and Prākṛta Paṇḍits who treat the Apabhraṁśa Kāvya with contempt.

The second part *i. e.*, vv. 1–4 and 51–74 on the other hand, is written in Prākṛta and in a comparatively concise style. No authorities are mentioned nor are there any covert allusions to Sanskṛta and Prākṛta Pandits in this part. This difference in language and style may indeed be explained by saying that the author of CK. merely followed the example of the Great Hemacandra who in his Cchandonuśāsana composes his illustrations of the metres in Sanskṛta, Prākṛta and Apabhraṁśa in those respective languages, and that the use of ornamental words and expressions was inevitable owing to the necessity of giving the illustration and the definition in one and the same stanza. But nevertheless such expressions as "Ajjuno Jampae" or 'Alhu payampai' or 'Gulhu payampai' and the fact that these authorities are mentioned in connection with metres which are very common and can in no way be described as first invented or introduced or even made popular by these authorities are very striking. Even the references to the SK. and PK. Pandits and their arrogance is very strange when we remember that Ratnaśekhara himself was a great Pandit of Sanskṛta and Prākṛta languages. From all these facts, it is therefore permissible to conclude that most of these stanzas *i.e.*, vv. 5–50 were not *composed* by Ratnaśekhara but merely *reproduced* by him from earlier works. It is very probable that the stanzas containing the names of Alhu and Gulhu were entirely quoted from a work or works on metre composed by these bards who were well known as poets (cf. vv. 12,27,30, 35). On this hypotheses alone can we properly explain the expressions like 'Ajjuno Jampae', 'Gosalena payāsio' &c. In their own work on metre, these poets must have inserted their names in every definition, as, for example Piṅgala does; and when Ratnaśekhara reproduced them bodily in his own work, the names also appeared there.

31. But in addition to these stanzas, which actually contain the names of either Alhu or Gulhu, there appear to be many more which also seem to have been reproduced by Ratnaśekhara from older sources. That our hypotheses is correct at least in the matter of CK. 12 is borne out by an independent evidence. This verse contains the definition of the strophic metre called Ṣaṭpada. It is almost wholly identical with PP. 107. There is, however, a significant change in the fourth line as occurring in PP. Instead of CK.'s 'Gulha Kavi erasa vuttau' we get in PP. 'Sesakai Vatthu Nivuttau'. The evident deduction from this fact is that Ratnaśekhara merely reproduced the stanza as it was, from Gulha's work, while PP. substituted his own name for that of Gulha and made it appear as though it were his own composition. It is on the other hand, impossible to imagine that the verse was originally composed by PP. and

reproduced from him by Ratnaśekhara either directly or indirectly. For the verse contains a second definition of the Ṣaṭpada, the first being given in v. 105, and is on that account regarded by one commentator (E. cf. page 185) as an interpolation. It is, therefore, probable that it did not originally belong to Piṅgala's text. But even supposing that it did, there is absolutely no reason why Ratnaśekhara should change the name Śeṣa to Gulha. Gulha is not Ratnaśekhara's own name nor is he in the habit of inserting his name in his composition like Piṅgala. There is thus a strong motive for changing the name on the part of PP. and not on that of CK. Further, to imagine that Gulha first appropriated the stanza from PP. by inserting his name and afterwards CK. merely reproduced it from him is very unsafe considering the state of the present text of PP. The conclusion, therefore, is forced upon us, that both CK. and PP. borrowed the stanza in question from Gulha's work which thus must be supposed to have once existed. The same may be said with reference to CK. 16 which is identical with PP. II. 208. In CK. the stanza does not contain any name but in PP. the name 'Faṇinda' is obviously inserted on purpose. The stanza did not evidently belong either to Ratnaśekhara or to Piṅgala. Both borrowed it from some older writer probably from the same Gulha's work, but PP. was anxious to pass it as his own and hence the insertion of the name 'Faṇinda'. Here the case against PP. is even stronger. If the stanza had been originally written by PP. and borrowed by CK. either directly or indirectly from him, there is absolutely no reason why the name 'Faṇinda' in the original should have been dropped by the borrower; and if we assume that it was done intentionally can we imagine that the borrower was so foolish or unimaginative that he merely dropped the name and did not substitute his own name for it at the same time to make the plagiarisation complete? Very similar indeed is the case of CK. 25 and CK. 31 which are practically indentical with PP. 170 and PP. 146 respectively. In CK. both the verses do not contain any name but in PP. they do contain the name of Piṅgala (Nāarāa Piṅgala and Sukaidiḍhabandhu *i. e.*, Piṅgala according to Commentator). Even here both seem to have borrowed from an older writer. CK. did it without any changes as he had no selfish motives, while PP. did make the necessary changes to pass off the verses as his own. There are two more stanzas *i. e.*, CK. 46 and CK. 50 which bear a close verbal similarity to PP. II. 69 and I. 144 respectively. These also appear to be borrowed by both from an older source but here PP. has made no changes whatsoever to serve his selfish purpose.

32. In all these cases I have assumed that both CK. and PP,

borrowed the stanzas from older sources. But it is not impossible to maintain that those stanzas in CK. which do not bear any name were composed by Ratnaśekhara himself and were borrowed from him by PP. The dates of CK. and PP. in its present form are indeed favourable for such an assumption; yet when the borrowing on the part of CK. is almost certain in the case of 15 stanzas which contain the name of Alhu or Gulhu, it must be assumed as probable even in the remaining part, particularly when both are written in the same style.

33. There are two more quotations in CK. They are from Piṅgala and are very interesting. CK. 4 defines Somakānta; its line contains 8 letters which are all long. The verse is, as shown above to be regarded as a quotation from Piṅgala but it is not found in its present text. On the other hand such a metre is called Viddyunmālā by Piṅgala (II. 66). The second stanza is CK. 45. It too is obviously a quotation from Piṅgala but is not found in the present text. It defines Hakkā whose line contains 30 Mātrās divided into three parts of 10, 8 and 12 Mātrās. Such a metre is known to Piṅgala but he calls it Catuṣpadī (PP. 97). Several conclusions can be drawn from the facts so far ascertained :—First that the text of Piṅgala which CK. had before it materially differed from the present one; second, that Piṅgala was not regarded as a great authority on Prākṛta metres at CK.'s time since only two stanzas are quoted from it and third that at CK.'s time there existed a work on the subject composed jointly (?) by Ariuna and Gosala both of whom were poets and obviously very popular ones.

H. D. VELANKAR

APPENDIX I.

Cchandahkośa of Ratnaśekhara.

The editon of Cchandahkośa is based upon three MSS. from the B. O. R. I., Poona. All the three contain the commentary by Candrakīrti. The first (A) was copied in Saṁ. 1931 at Vikrampur in Marwar by Bhaṭṭa Gopīkṛṣṇa from an older MS. dated Saṁ. 1624. The second (B) was copied in Saṁ. 1697 by Muni Mohana. The Third (C) was copied by Roycand in Saṁ. 1667. A (No. 75 of 1873–74) has 23 folios: B. (No. 448 of 1892–95) has 24, while C (No. 591 of 1884–86) has only 13. All of them are good MSS.

अथ श्रीरत्नशेखरसूरिविरचितः छन्दःकोशः ।

आजोयणल्लियाणं सुरनरतिरियाण हरिससंजणणी ।
सरससरवन्नछंदा सुमहत्था जयउ जिणवाणी ॥ १ ॥
भूचंदक्कमरुग्गणा मभजसा सव्वाइमज्झंतगा
गीयाइसु कमा कुणन्ति सुसिरिं कित्तिंच रोगं भयम् ।
सग्गंभोगिणिखेसरा नयरता सव्वाइमज्झंतला
आऊबुद्धिविणासदेसगमणं कुव्वंति निःसंसयम् ॥ २ ॥
छंदवसा दीहपरा कत्थवि लहुआ हवन्ति पयअन्ते ।
एंओइहि बिंदूविअ रहवंजणजुत्तिपुव्वो य ॥ ३ ॥
नायाणं ईसेणं उत्तो । सव्वेहिं दीहेहिं युत्तो ।
मंमंगंगं पाठिज्जंतो । एसो छंदो सोमक्कंतो ॥ ४ ॥
वेयमिए भगणेहु ठविज्जहु । दोधक छंदह नाम मुणिज्जहु ।
सोलस दीहपमाण विजाणहु । मत्त चऊसठि सोजि वरवाणहु ॥ ५ ॥
तुरंगमआउसमा लघु दिज्ज । कला ससिसंख य ते गुरु किज्ज ।
जगन्नइ होइ पयासु विसामु । सुगुल्ह पयंपइ मुत्तियदामु ॥ ६ ॥
सगणा इह तोटक छंद धुयं । गुरु सोलस तीसंदुयं लहुयं ॥
चउसट्ठिवि मत्त थ संठवियं । अठतालिसअक्खरबंधवियं ॥ ७ ॥
पइ पइ लहु सयल । पडहिं जहिं अविरल ।
तहिं नगणवि ठवहु । जय बहुलु सु भणहु ॥ ८ ॥
लहू सोलसा दीह बत्तीस दिन्ने । असी मत्त चौवीस दूबार वंन्ने ।
अयं मन्नणीओ भुजंगप्पयाओ । यगण्णेहिं संजुत्तओ छंदराओ ॥ ९ ॥
मत्त अस्सीइ रग्गण्णसंजुत्तयं । दीह बत्तीस जोएह नीरुत्तयं ।
सव्वछंदाण मज्झंमि अइमोहणं । अज्जुणो जंपए कामिणीमोहणं ॥ १० ॥
जाणेहु सद्धाइं चालीसवन्नाइं । चंदू लहू दीह दोतीस पुन्नाइं ।
अस्सीइं मत्ताइं तग्गण्णु जाणेइ । छंदंपि मेणाउलं अल्हु जंपेइ ॥ ११ ॥
जसु पइपइहिं निबंध मत्त चउवीसइ किज्जइ
अक्खरडंबरसरससुद्ध तं छंदं भणिज्जइ ।
छक्कलु आइहि होइ चारिचउकलैंसंजुत्तउ
दुक्कलु अंति निरुत्त गुल्हकवि एरसं वुत्तउ ॥
बावन्नसउवि मत्तइ रयैहु उल्लालइ सरिसउ गणहु ।
छप्पयह बंध एरिसुं हवइ काइं गंथ गंथिय मुणहु ॥ १२ ॥

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(१) ०ल्लिआणं B ; (२) तिरिआण B; (३) ०वण्ण० A; (४) एऊहिं बिंदू० C; (५) जुत्तो A; (६) चउस्सठि A; चउसाठ्ठि C; (७) वषाणहु B; (८) पयास विसाम A; पयास विसामु C; (९) मुत्तियदाम C; (१०) तीसदुइं A; (११) चउवीस A; C; (१२) वण्णे A; (१३) सुद्धाइं A; (१४) वण्णाइं A; (१५) पुण्णाइं A; (१६) छंदु A; (१७) चउकलिहि संजु० A (१८) दुक्कल B; (१९) निरुत्तु A; (२०) एरिसि B. (२१) रइवि A; (२२) एरिसो B, एरिस C.

सुच्चिय छप्पयबंध चरमउल्लालइ वज्जिउ
वत्थुयनामि हवेइ छंदु चहुंचहुं पइ सज्जिउ ।
सो पुण देसीभाससरसबहुसद्दसमाउल
रोडक नामि पसिध्दु छंदु कवि पढहिं रसाउल ॥ १३ ॥

नरायपाय वीस मत्त चारिमत्त अग्गला
ठविज्जयंति सोलसाइं अक्खराइं निर्म्मला ।
लहू य अठ्ठ दीह अठ्ठ एरिसो पसिद्धओ
नरायनाम सोमकंत गोसलेण दिठ्ठओ ॥ १४ ॥

पए पए सु तीस मत्त वीसवन्न जुत्तओ ठविज्जए
बिसुत्तरो सओ वि मत्त ईक्कमेलि ठामि ठामि किज्जए ।
सुसुद्ध छंद सुक्खकंद लोयणंददायरो सुडामरो
नरायनाम अज्जुणेण भासिओ सु तत्थ पंचचामरो ॥ १५ ॥

डुमिलाहि पयासम मत्तविसेसेण होई तहिंच्चिय चारि भणू
भणु मत्त बतीस बतीस थ मेलवि अठ्ठहि ठामि ठवे सगणू ।
गणु अन्ने न लिज्जइ सोवि ठविज्जइ तं फुड जाणि निभंतिकेरी
करि जमकु विसाइण पाइण पाइण सुठ्ठुवि छंदुवि तंजिपरी ॥ १६ ॥

मत्त हुवइ चउरासी चउपइ चारिकल
तेसठिजोणि निबंधी जाणहु चहुयदल ।
पंचक्कलु वज्जिज्जहु गणु सुठ्ठुवि गणहु
सोवि अहाणउ छंदु जि महियलि बुहं मुणहु ॥ १७ ॥

अडवीस मत्त निरुत्त जहि पयबंध सुंदर दीसए
सउ बारहुत्तर मत्त चहुपइं मेलु जत्थ गवीसए ।
जो अत्थलीणउ जमगसुद्धउ गोसलेण पयासिओ
सो छंदु गीयउ मुणहु गुणियण विमलमइहि जुं भासिओ ॥ १८ ॥

विजयक छंदो । सुक्खकंदो ॥
लहुगुरुसहिओ । अज्जुणि कहिओ ॥ १९ ॥

बिबि पय सोलस मत्त कहिज्जइ
पंचदहं पुण बेबि रइज्जइ ।
बासठि मत्तह जासु पमाणु
सो छंदउ फुडु बेसर जाणु ॥ २० ॥

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(१) थज्जिउ B; (२) चउंचउं पइ B; (३) नामि पसिद्ध A; नाम पसिद्ध C. (४) णिम्मला A; (५) the word इक्कमेलि is dropped in A. (६) सुचामरो B; मुझामरो C; (७) मतविसेसिण C; (८) होहि A; (९) अण्णण A; (१०) सोइ A; सो A; (११ (निभंतकरी B; (१२) विसायण पायणपायण B; (१३) छंदवितंजि B ; (१४) चउपय A; B; (१५) निबद्धा B; निबद्धी C; (१६) गण A; C; (१७) हाणउ B; मुहाणउA; (१८) बहु A; C; (१९) जमकसुद्धउ A; (२०) छंद B; (२१) सु A; (२२) सोलह A.

तेरहमत्ता विसमपइ । सम एयारह मत्त ॥
अडयालीसं मत्त सवि । दोहा छंद निरुत्त ॥ २१ ॥
आइल्ले दीहा लहू । बावीसं चत्तारि ॥
इक्किक्क दीहा हरी । दोहा नामुच्चारि ॥ २२ ॥
हंसु वराहु गयंदु पहु । पिंगलु तरलु तमालु ॥
सायरु सुंदरु मेरु नरु । कुंजरु हरु सुकुमालु ॥ २३ ॥
दमणउ मरुवउ अहि पवणु । घणु विज्जू आणंदु ।
आमूलउ बावीसमउ । कहउ जु जाणइ छंदु ॥ २४ ॥
सो सोरठ्ठउ जाणि । जो दोहा विवरीय हुइ ॥
बिहुं पइं जमकु वियाणि । इकु पहिलइ अरु तीसरइ ॥ २५ ॥
दोहा छंद जु पढम पढि । मत्त ठविज्जहि पंच सुरेहा ॥
चूलियाउ तं बुह मुणहु । गुल्हु पयंपइ सव्वसुएहा ॥ २६ ॥
दोहा छंदु जि दुदल पढि । दहदहकलसंजुत्त सु अठसठि मत्त सवि ।
उवचूलिय तं बुह मुणहु । लहुगुरुगणसंजुत्त सु जंपइ अल्हकवि ॥ २७ ॥
तिहिमत्त मत्त जहि पढमपउ । बीयउ रुद्दयजुत्त ॥
पुव्वद्धु जेम तिम उत्तरवि । सो उग्गाहु निरुत्त ॥ २८ ॥
मत्त इगारह मिलिय पुणवि दह संचलिय
पयंपय इणि परिकलिय गुरुवि लहु संकलिय ।
सुणवि सवणमणिरलिय जीहं जहिं नहुं खलिय
सुदिढबंध न हु टलिय अत्थसंगह मिलिय ॥
तह चालसउवि मत्तइं रयहु गुल्ह पयंपइ नियरलिय ।
रासाउल छंद जु एह हुइ कांइ कविय डंखहि अलिय ॥ २९ ॥
पयपयह मत्त, बत्तीस दिंत, लहुगुरुविचित्त चउकलयजुत्त
बहुजमगसुद्ध जाणहु निरुत्त बहुअत्थजुत्त कवि अल्हिउत्त ।
सव्वत्थ मत्त किज्जहि इकत्त सय इक्क ठाणि अडवीस जाणि
छाणवइ जोणि पायडिय खोणि एरिसि य वाणि दंडक्कु जाणि ॥ ३० ॥
दोहा छन्दु जि पढम पढि । कव्वह अद्ध निरुत्त ॥
तं कुंडलिया वुह मुणहु । उल्लालइसंजुत्त ॥
उल्लालइ संजुत्त जमगसुद्धउ सलहिज्जइ
चउवालसउवि मत्त सुदिढपइपंथ रइज्जइ ।
उल्लालइ संजुत्त लहइ सो निम्मलसोहा
तं कुंडलिया छंदु पढम जहि पढियइं दोहा ॥ ३१ ॥

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(१) विवरी हुवइ B; (२) अनु A; (३) चूलिआउ B; (४) गुल्ह B; गुलु C; (५) दुदलि B; (६) बहु C; (७) अल्हवि B; (८) जुत्तु C; (९) उग्गाह B; (१०) इग्यारह B; (११) पइपइ C; सुपयपय A; (१२) इण B; (१३) सुवाणि C; (१४) जहिंजाहिं A; (१५) नउ B; (१६) रलिय B; (१७) हुत C; (१८) पइपइमत्त० B; (१९) अल्ह B; (२०) छाणवहु A; छाणवय C; (२१) उल्लालयसंजुत्त B; (२२) सुलहि० B; (२३) पयपंथ B; (२४) पढिया A; C.

सो चंदायणु छंदु फुड्डु । जहि धुरि दोहा होइ ॥
अइकोमलु जणमणुहरणु । बुहियणसंसिउ सोइ ॥
बुहियणह संसियउ सोइ सलहिज्जए
कामिणीमोहणो पुरउ पाठिज्जए ।
मत्त अडवीससउ जेण विरइज्जए
सोवि चंदायणो छंदु जाणिज्जए ॥ ३२ ॥

दोहा छंदह तिन्नि पय । पढमेइं सुद्ध पढेहु ॥
पुणवि चउत्थवि गाहपेउ । वेरालुवि तं वियाणेहु ॥ ३३ ॥

तिहिंहिं मत्तउ पढमु पउ होइ । तह तीयउ पंचमउ ॥
बीय चउथु रुद्दय निरुत्तउ । सतसट्ठिवि मत्त निरु ॥
सुकवि अल्हि राढउ सँ उत्तउ ॥
इकु राढउ अरु दूहडउ । बिहुं मिलि वत्थुवि होइ ॥
पणरुत्तरसउ मत्त थिरु । विरलउ बुज्झइ कोइ ॥ ३४ ॥

पइ पइ होइ मत्त अडवीसवि छक्कलु आइ किज्जए
मज्झ थ पडहि पंच चाउक्कलु दुक्कलु अंति दिज्जए ।
चउरासी सुजोणिसंजुत्तउ लहुगुरुगणविसुद्धओ
तं दुवई य छंदु सुहलक्खणि अज्जुणि सुकइ वद्धओ ॥ ३५ ॥

पय चारि ठविज्जहि सासिहि मत्त
पाँऊहरु गणु जइ होइ अंत ।
चउसट्ठि कलइ सव्वेइ गणहु
पद्धडिय छंदु तं बुह मुणेहु ॥ ३६ ॥

पइ पइ होई[13] तीस ध्रुवमत्तइ अक्खरडंबरजुत्त
चउकल थ सत्त ठवि ठामय ठामय दुक्कलु अंतु निरुत्त ।
जइ नवइ जोणि षोणि थ सुपसिद्धा पढत थ अइसउ छंदु
वीसोत्तरसउ जहि मत्त निरुत्तउ सो चउपैइया छंदु ॥ ३७ ॥

पढिऊण पढम गाहा पुरओ पढिऊण कव्वपयजुयलं ।
उल्लालयसंजुत्तं कुंडलिणी होइ सुनिरुत्तं ॥
तं कुंडलिणि निरुत्त मत्तँ तेवनसउ किज्जइ
दिढबंध थ संजुत्त अद्ध पाय थ सु ठविज्जइ ।
उल्लालयसंजुत्त एणिपरि बुहियणु किज्जइ
तं कुंडलिणीछंदु पढम जहि गाह पढिज्जइ ॥ ३८ ॥

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(१) चंद्रायण छंद A; C; (२) मणहरणु A; C; (३) संसिय B; (४) कामिणीमोहणं B; (५) पढमं B; (६) गाहपय B; (७) सुतउ उत्तउ B; ०सु उत्तउ C; (८) वत्थू होइ B; (९) पग चारि C; (१०) पाउहर जगणु B; (११) सव्व B; (१२) पद्धडी छंद B; (१३) पइ पइ होइ A; B; C; (१४) धुवमत्तइ A; C; ध्रुवमत्त B; (१५) चउपया छंदु B; (१६) कुंडलिणी० A; (१७) मत्त is dropped in B; (१८) दृढबंध B.

सो चंदायणिछंदो जेण पढिज्जंति पढम गाहाओ ।
कामिणिमोहण पुरओ मत्ता अस्सीय संजुत्तो ॥
मत्त अस्सीई (जुय) होइ नीरुत्तयं
पंचकल सव्व ससिकल थ संजुत्तयं ।
कामिणीमोहणो पुरउ पाठिज्जए
सोवि चंदायणी छंदु सलहिज्जए ॥ ३९ ॥
सट्ठि थ मत्तह होइ निरुत्त । चउपय पंचकल थ संजुत्त ॥
पनरह मत्तह पयह पमाणि । लघुचउपइया छंदु वियाणि ॥ ४० ॥
चउपइ इक्कु जमक्कुवि दीसइ । अडिल छंद तं बुह थ सलीसइ ॥
जमकु होइ जहिं बिहुपयजुत्तउ । मडिल छंदु तं अज्जुणि वुत्तउ ॥ ४१ ॥
पइपइ अन्नु जमक्कु रइज्जइ । सोलस मत्त पमाणवि किज्जइ ॥
सव्वमत्त जगणुवि चिंतिज्जइ । भिन्नमडिल्ल नाम तसु दिज्जइ ॥ ४२ ॥
पय पढम समाणउ तीयउ जाणउ ।
मत्त अढारह उद्धरहु ॥
बिय चउथ निरुत्तउ तेरह मत्तउ ।
घत्त मत्त बासठि करहु ॥ ४३ ॥
सव्वाणं दीहा सोहाणी । बासट्ठी मत्ता मेहाणी ॥
आणीया छंदा रेहंणी । सा पत्तामेहा मेहंणी ॥ ४४ ॥
ससिमत्तपरिट्ठिउ अंसगरिट्ठिउ मुत्तिउ अग्गलि जासु
जणबंधहं सारी सव्वपियारी निम्मल लक्खण तासु ।
जणुं पंडिउ बुज्झइ तासु न सुज्झइ इक्क वियाणउ तेओ (भेओ)
सुवि जंपिवि नत्तहं चिंतवयंतहं भासइ पिंगलु एओ ॥ ४५ ॥
पवाणि अट्ठ अक्खरा । लहू गुरू निरंतरा ॥
पवाणि दूणियाणए । नरायछंदु जाणए ॥ ४६ ॥
दहमत्त पउ किज्ज । पंचयल सुठविज्ज ।
जो पढत सुहकंदु । एयावली छंदु ॥ ४७ ॥
पुव्वद्धउ पढि दोहडउ । पच्चद्धउ गाहाण ।
चूडामणि जाणिज्जहु मज्झे सयलाण छंदाण ॥ ४८ ॥
ठामि ठामि चउपय लघुजुत्तउ । तियलु पंचयलु वेवि निरुत्तउ ॥
सयलमत्त चउसट्ठि किज्जए । मालई थ छंदो मुणिज्जए ॥ ४९ ॥
ठवि पउमावत्ती ठाणं ठाणं चउमत्ता गण अट्ठा ये
धुवकन्ना करयलचलणे विप्पो चारे गेणे उक्किट्ठा ये ।

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(१) चंदाइण C; चंदाइणि A; (२) असीय B; (३) असीइजु B; (४) निरुत्तयं A; B; (५) कामिणीमोहणं B; (६) छंद A; C; (७) बिहुपइजुत्तउ B; (८) मडिल्ल B; (९) तीज B; (१०) रेहाणी—A; B: C मेहाणी A; B; C; (११) जण B; (१२) विआणउ तेओ B; (१३) पंचकल B; (१४) सुहकंद B; (१५) छंद–B; (१६) वा निरुत्तउ A; C; (१७) य A; (१८) करयलचलणो A; B; (१९) गुण C.

जइ पडइ पओहर हरइ मणोहर पीडइ तह नायक्कतणूं
नयैरहं उव्वासइ कवि निन्नासइ छंदह लावइ दोस घणूं ॥ ५० ॥
सामन्नेणं बारस अट्ठारस बार पनरमत्ताओ ।
कमसो पायचउक्के गाहाए हुंति नियमेणं ॥ ५१ ॥
गाहाइ दले चउचउमत्तंसा सत्त; अट्ठमो दुकलो ।
एवं बीयदलेविहु नवरं छट्ठोइ एगकलो ॥ ५२ ॥*
पढमदले छट्ठंसो गुरुमज्झे होइ सव्वलहुओ वा ।
विसमंसो पुण दोसुवि दलेसु न हु होइ गुरुमज्झे ॥ ५३ ॥*
विसमंसा चउभेया दुइओ तुरिओ य हुंति पंचविहा ।
दुविहेगविहो छट्ठो एगविहो अट्ठमो अंसो ॥ ५४ ॥*
छव्वीसं पत्थारयगाहा चत्तारि जाइगाहाओ ।
पंच य सहावगाहा विसेसगाँहाउ चत्तारि ॥ ५५ ॥
लच्छी कित्ती कंती गंगा गोणी कुरंगिणी खोणी ॥
लीला ललिया रंभा बंभाणी मागही मेहा ॥ ५६ ॥
माला बाला हंसी वीणा वाणी तरंगिणी तारा ।
सिद्धी बुद्धी रिद्धी गंधर्वी किंनरी जुण्हा ॥ ५७ ॥
तीसं वन्ना सत्तावीसं दीहा य तिन्नि[3] अट्टीहा ।
जीए सा आइल्ला नायव्वा होइ एयासु ॥ ५८ ॥
ललियतर मिलियअविरलबहुलहुयरनियररइयउभयदलम् ।
हुयवहसरमियलहु गुरुदुगजुयमिह मुणह चरमयरम् ॥ ५९ ॥
लच्छी विप्पी; मेहा सुद्दी; जाणेह खत्तिणी एसा ।
पडुपयडियवरलहुयरविरइयपयपवरचरमदला ॥ ६० ॥
पढमदलमिलियनिरुवमलवणिमगुणनिउणलहुयपहियतणू ।
पच्छद्धे दीहेहिं जासा जा सा वइस्सी सा ॥ ६१ ॥
पढमतइज्जा पाया बारसमत्ताउ नेव लंघंति ।
जीसे सा गाहाविय सहावओ भन्नए पत्था ॥ ६२ ॥
जीए पुण पढमतइज्जएहिं पाएहिं लंघिया मत्ता ।
सा विउला नाम कईहिं दंसिया छंदसत्थंमि ॥ ६३ ॥*
जीए दलेसुं दोसुंपि दोचउत्थया हु गुरुमज्झे ।
दीहंसरुद्धपासा हविज्ज सा नूणमिह चवला ॥ ६४ ॥*
एसो विही य जीए दलंमि आइल्लयंमि होइ फुडम् ।
मुहचवला नाम भवे सा गाहा इत्थ छंदंमि ॥ ६५ ॥*
एसोवि विही जीए सव्वोवि हविज्ज उत्तरदलंमि ।
सा होइ इत्थ गाथा जयंमि नूणं जहाचवला ॥ ६६ ॥*

(१) नयरहुं B; (*) These verses are not found in B; (२) विसेसगाहाओ A; (३) तिण्णि A.

सा पुण विसेसरूवा होइ विगाहा फुडं लोए।
जा गाहावि पढिज्जइ कईहि विवरीयउभयदलकलिया ॥ ६७ ॥ *
जीसे पढमिल्लदले तीसं मत्ताउ तीस बीयदले।
सा सट्ठिमत्तकलिया गीई भणिया जयंमि विबुहेहिं ॥ ६८ ॥ *
सगवीसं सगवीसं मत्ताओ दलजुगे जत्थ।
सा चउवन्नसुमत्ता उवगीई गिज्जए लोए ॥ ६९ ॥ *
बासट्ठी मत्ताओ कहियाओ गाहिणीइ छंदम्मि।
बारट्ठारसबारसवीसं च कमेण चउसु पाएसु होइ † फुडं † ॥ ७० ॥
पत्थारछंदसंखा एगूणा अक्खराइसंजुत्ता।
गाहाणं दूहाणं अक्खरसंखं पयासेइ ॥ ७१ ॥
वन्नो निराइदुगुणा लहुआइजुआ कहंति लहुसंखं।
वन्नविसुद्धा मत्ता फुडं पयासंति गुरुसंखं ॥ ७२ ॥
पयडेइ छंदसंखं अक्खरसंखा अणाइ एकजुआ।
छंदाणं जोणीओ जाणह पाऊणमत्ताए ॥ ७३ ॥
इय पाइयछंदाणं कइवेयनामाइं सुप्पसिद्धाइं।
भणियाइं लक्खलक्खणजुयाइं इह छंदकोसंमि ॥ ७४ ॥
इति श्रीरत्नशेखरसूरिविरचितः छंदःकोशः समाप्तः ॥

APPENDIX II.

Brief Notes.

(३) रहवंजण० A letter preceding a conjunct containing र or ह as its first syllable. (५) वेयमिए–वेदमितान्, i. e. 4. (६) तुरंगमआउ = 32 years. (७) तीसदुयं i. e 32. मत्त=मात्रा; थकारः पादपूरणार्थः (९) असीमत्त, 80 mātrās. चोवीसदूबार, i. e. 48. (१०) अइ in the 3rd line stands for a long letter. (१२) काइं गंथ०–अहो ग्रंथिकाः संस्कृतकाव्यवेत्तारो यूयं किं जानीत। अपभ्रंशस्य सांस्कृतिकैरनादृतत्वात्तत्प्रत्यवज्ञावचनमिदम्—Com. (१३) देसीभास०–अपभ्रंशादिमय्या भाषया० (१५) पयासम–पदाश्रमाः पदविश्रामाः 'There are four *rests* in a pāda.'– A; the four rests are the fours yatis. विसाइण पाइण–विशिष्टेन पादेन पादेन सह यमकं कुरु–Com. It should be noted that in the last line, the letters जम in 'करिजमकु' stand for a long letter required for the first Sagaṇa. (१७) चउपइ चारिकल–चतुर्षु पादेषु प्रान्ते चत्वारः कलाः लघुरूपाः भवन्ति। 'अत्रापि पादे पादे प्रान्ते लघुत्रयं भवत्येवेत्याम्नायः।'—Com. योनि is a technical name given to $1\frac{1}{3}$ mātrā; c.f. v. 73 below. Thus, 1 mātrā=$\frac{3}{4}$ yoni.

(*) These verses are not found in B; (†) The words होइ फुडं are not found in B; (१) वन्नाइतिराइ दुगुणा B; (२) कइवइनामाइं B; (३) सुपसिद्धायं B; (४) जुयायं B.

(२६) 'अत्र पञ्चमात्रास्थाने यगणो वा लघुगुरुलघुद्वयरूपं वा भवतीत्याम्नायः-Com. सुकेहा (?) सव्व सुएहा (?) (२८) तिहिमत्त मत्त—तिथिमात्राः मात्राः i.e. 15. (२९) In the first four lines, the yati seems to be intended after the 11th mātrā. (३०) पायडिय खोणि क्षोण्यांप्रकटाः (३५) सुहल०=शुभलक्षणेन अर्जुनेन सुकविना बद्धम् । (३७) षोणि थ सु०=क्षोण्यां सुप्रसिद्धम् । पढत थ०=पठतामति । सु i. e. सुखं छन्दः । (३८) तत्रार्धपादे पादार्धे स्थाप्यते स्नानं यतिः क्रियते—Com. Perhaps it is अड्ढपाय. (४१) सलीसइ (?) (४२) चिंतिज्जइ= त्यज्यते पादान्ते इति शेषः—Com. (४४) ' यत्र सर्वेपि दीर्घा भवन्ति नवरं तृतीयचतुर्थयोः पादयोः सप्तमो लघुर्भवति सा मेहाणीति भवति कीदृशी प्राप्तमेधा मेधया प्राप्ता—Com. (४५) ससिमत्त = 16 Matras; अंस = a long letter; मुत्तिअ = ' मौक्तिकं द्वादशमात्रकं कथ्यते '—Com. तासु न सुज्झइ = तस्य सामान्यपण्डितस्य न शुध्यति—Com. The fourth line is difficult. The com. on it is:—' भेदं विजानीत भो बुधाः तज्जल्पते निश्चयेन पिङ्गलः एतद्भाषते ' (५०) Out of the five kinds of Caturmātras only four are allowed, namely, कर्ण SS; करतल IIS; चरणः SII and विप्र IIII. पयोधर ISI is to be avoided. Last line is difficult. (५१—७३) See Gāthālakṣaṇa of—Nanditāḍhya, Annals, B. O. R I., Vol. XIV, p. 1 ff; where the subject is fully discussed.

FAZENDARI TENURES

(1) *Short History*:—

We intend in this article to deal with the land. tenure well known in Bombay as " Fazendari tenure " the exact nature of which does not yet seem to be clearly understood, though it is unquestionably of long standing. It is not known how and when it originated. The history of the tenure, for all practical purposes is, however, well known from the date of Aungier's Convention in 1672. From the history of the Mazagaon estate given by Mr. Vaidya in his Bombay City Land Revenue Act, (1931) Second Edition at p. 68 and sequel, the estate appears to have become vested in the East India Company somewhere in the middle of the 17th century and subsequently farmed out by the Collector of Bombay from towards the end of the 18th century. It is not necessary in this short article to enter into a detailed account and history of this tenure from its very commencement. It is enough to state, that it is a tenure closely connected and associated with the Pension and Tax tenure and is said to be a *sub-tenure between a private proprietor and his tenant. The tenant has a right to occupy the land on payment of rent to the landlord proprietor.* It is interesting to note that according to the Gazetteer of Bombay City and Island (1909) Edition Volume II, pp. 338 to 340, cited in extenso by Mr. Vaidya ni his said book, at pp. 93–94, though this is a tenure distinct from the Pension and Tax tenure, it is classed as coming under the same and it is referred to by saying " closely associated with the Pension and Tax tenure is a kind of sub-tenure known as 'Fazendari tenure'. Mr. Dandekar in his book on Land tenures in the city of Bombay and in the Presidency (1912) Edition, Vol. I, pp. 567–569, also refers to this tenure in precisely the same terms. The Collector's records also do not recognise any such tenure as 'Fazendari tenure' under such name and no separate rent roll is kept therefor. It is, however, merely classified under the leasehold tenure."

(2) *Meaning of the words " Fazendari " and " Fazendar "* :—

The Portuguese word " Fazenda " means an estate holder, a landlord or proprietor. The words " Fazendar " and " Fazendari " are corruptions from the above Portuguese words. According to the meaning of the original Portuguese words " Fazendari " means an estate generally. But by custom it seems to have acquired a peculiar meaning. In the Bombay Gazetteer cited as stated before

by Mr. Vaidya in his said book at pp. 93–95, the Fazendari tenure is described in the following words:—"Closely associated with the Pension and Tax tenure is a kind of sub-tenure known as 'Fazendari'. It is a sub-tenure between a private proprietor and his tenant. It is not known how and when it originated, but it is unquestionably of long standing. The owner of the land under Government is known as the Fazendar. Land under this tenure was let for building purposes, without, in most cases, any formal agreement, and subject to a low annual ground rent. The earliest record of this tenure found in the Collector's office is a report by the Veraadors dated the 14th December 1782. It runs as follows:—
"The rule and custom practised at the island are:—

(*a*) That the owners of the oarts cannot break or remove any house in their oarts, unless the owner of the house has given just cause to or any ways causing damage to the oart or its owner.

(*b*) That no owners or possessors of the houses can sell their houses to any strange purchaser without a special permission of the oart's owner and should he, the owner, choose to buy the house, he is to have preference at a moderate rate according to the time and value or at an intrinsic valuation at the time.

(*c*) That no persons living in another person's oart can on any account let out their houses to any improper or indecent people any way detrimental or scandalous to the owner of the oart or the neighbourhood and on their, the owners of the house, acting so, the owners of the oart may thereby order the house to be removed, but the house must not exceed the value of Rs. 500.

(*d*) That no persons in another person's oart can take any further ground for their houses' use or open any new passages without the owner's permission previously obtained nor can they pretend, should there be bamboo or mud-walled houses, to make them of chunam and stone or to rebuild them with timbers without the owner's permission.

(*e*) When any person builds a house in another person's oart, they make no other agreement with the owner, but that of paying annually the usual ground rent thereof or as they may have settled betwixt them and to live quiet and peaceably without giving the least trouble, determent or any scandal to the owner of the oart or neighbourhood or causing any . . . . . . trouble . . . . . . damage to the owner."

"But long prescription appears to have changed the nature of this tenure altogether. It was a popular idea with some of the old native proprietors that the Fazendar, although he could on no account evict his tenant while his building was standing had a

reversionary right to his land as soon as it was either pulled down or destroyed by fire or other natural causes."

The earliest and leading case reported on the subject is the case of Doe Dem Dorabji *v.* Bishop of Bombay (1848) Perry's Oriental cases, p. 498 in which Perry C. J., held that the true meaning of Fazendari land was, land not belonging to Government. This was an action of ejectment to recover a portion of vacant ground at Sonapur which had been formerly occupied by a house bought by the Bishop of Bombay for religious purposes in 1843, for the sum of Rs. 1,250, subject to the payment of Rs. 8 per annum to a person called the Fazendar, who was the lessor of the plaintiff. The Bishop pulled down these two houses with a view to erecting a school or other building connected with some religious society. The lessor of the plaintiff *viz.* the Fazendar of the soil had purchased his Fazendari right in 1838. Upon the Bishop proceeding to rebuild the house without having obtained the permission of the lessor, as Fazendar, the latter claimed a right as such to eject him, and recover possession, now that the building, which formerly stood upon it, had been pulled down, and accordingly, duly served the defendant with a notice to quit. The defendant having failed to comply with the requisitions of the plaintiff, the plaintiff brought the present action on the ground, that the Bishop had no right to rebuild after he had received a notice to quit from the Fazendar. It was contended on behalf of the plaintiff, that the payment of rent by the holders of the houses raised a presumption that they were merely tenants from year to year, and that the landlord had consequently a right to determine their tenancy at any time upon giving them half a year's notice to quit, or, secondly, that according to a general understanding which had acquired the force of a custom in this island, the term, which the owners of the houses had in the land, on which the houses stood, was to be measured by the duration of the houses themselves, and that the tenant had no right to make such repairs as amounted to a renovation of the house, without the license of the Fazendar, which he might either grant or withhold at his pleasure. The defendant, on the other hand, contended that he had a right to erect other buildings on the land and to hold the same in perpetuity upon continuing to pay to the fazendar the yearly rent which was paid by the former owners of the houses which had been removed or that at the most, the lessor of the plaintiff could only demand a reasonable increase in the rent, or a reasonable fine for permission to rebuild, but that he had no right to resume possession of the land.

It was held by Perry C. J., Yardley J. dissenting that a Fazendar, who had no other title to the land than the receipt of a small

quit rent, was not entitled to eject the tenant on the latter's pulling down his house and rebuilding the same without permission. Perry C. J., delivering judgment, in connection with the origin of the tenure and the relation created by virtue thereof between the parties concerned said at pp. 504 and 505 : "The origin of the relation between Fazendars and house-holders, where the possession is ancient, and no proofs of a contract are forthcoming, is altogether unknown. Whether the Fazendars were the original owners of the soil, or mere cultivators and farmers holding of other persons, such as the Jesuits, and religious houses, once existing in Bombay; whether the house occupiers have encroached upon the Fazendars, and have turned their permissive right to occupy into an indefeasible right, on certain conditions like the copy-holders and tenants of the Northern manors in England: or, whether the Fazendars have encroached upon the Government, and usurped the right to claim the Government assessment from the tenants, it is by no means easy to say. I believe that occasionally the one state of facts has occurred, occasionally the other. From what we know of the state of the island at the time of the cession, (of Bombay by the Portuguese to the British Government in the year 1662) it was occupied by only a few thousand souls, 10,000 according to Dr. Fryer who visited the island in 1671, and who then found the population much increased by a mixture of people from the neighbouring countries, most of them fugitives and vagabonds. The soil of the island, except in the portions built over in the Native town, Mahim, and Mazagon, was swampy, or covered by the sea in the low portion of the island, or barren uncultivated ridges in the remainder.

Judging from analogy in other parts of India, such uncultivated ground would belong to Government, not to private individuals. The terms "Fazenda" is not significant in any oriental tongue, and is plainly derivable from the Portuguese word "Fazendeiro," which, in Vieyra's Dictionary is Englished "a cultivator, a tiller, a husbandman," and never seems to be used to designate a proprietor ; and it does not appear that the Portuguese law contains any trace of a tenure similar to that called Fazendari in Bombay. The system therefore, in all probability, has grown up in this island during the last 200 years by much usurpation on either side ; and as in all cases of usurpation, which by long efflux of time has given birth to a right, the extent of the respective rights which have arisen must be measured by the actual usage which has taken place." (The learned Chief Justice then referred to the evidence of the plaintiff's witnesses and after remarking that, not one of them was able to adduce an instance in which, a Fazendar had exerted the right, which they all said, he possessed, of turning out the occupant of a substantial house which had been enjoyed time immemorially and then went on to explain

the true meaning of the expression "Fazendari land" and observed at p. 505 of the report:—"*The true meaning of the expression Fazendary land is land not belonging to Government.* The classification has its origin entirely in the mode in which the Government assessment is made. A different rate of tax, pension, or assessment, is applicable to Government land and to Fazendary land, and the accounts are kept distinct. But in this distinction the Government have not sought, nor have they been interested, to define what the rights of the private parties holding Fazendary lands are. And thus a Fazendar occupying and tilling land himself and paying a fixed rent to Government; or one making contracts with tenants to occupy the Fazendary land on terms to be agreed between them; or one merely receiving a certain fixed sum by virtue of ancient usage, are all Fazendars in the eye of Government, and in the popular language of the Bazar. But in these three persons we perceive three different characters, with wholly different legal relations attachable to them, and for the most part equivalent to our English notions of a tenant in fee simple holding of a superior lord by rent service, a landlord demising at rack rent, and a party seized of an ancient rent issuing out of the land."

Yardley J. also agreed with the learned Chief Justice that the origin and extent of the rights of the Fazendars were involved in obscurity and that the means of dispelling that obscurity did not exist. After setting out the various contentions on behalf of the plaintiff and the defendant, he went on to explain the meaning of the word " Fazendar " and observed at p. 508, in this connection:

"It appears, however, that the word " Fazendar ", in the Portuguese language, means a " farmer ", and that all the land in the island of Bombay, whether built upon or not, consists either of what is called " Fazendary land ", or of " Government land "; but it is doubtful whether this distinction, so far as it implies a diversity of tenure, be a sound one. For the Fazendary land pays a " pension " or tax to the Government, as well as the Government land, and I have observed in the course of this trial, that in every instance in which reference has been made to an immediate landlord, other than the Government, he has been termed the Fazendar, and though, at the time of the cession of Bombay to the Crown of England, and for sometime afterwards, the term may have implied a peculiarity of tenure, *I incline to think that, at the present day, it implies no more in common parlance, than that the individual so designated is the immediate landlord of the person who actually occupies the land,* and the fact, that the piece of land which the plaintiff seeks to recover, is called " Fazendary ground ", does not further assist us in ascertaining the relative rights of the person

entitled to receive the rent payable in respect of the land; that is to say, the plaintiff, on the one hand, and of the person who represents those who were the owners of the buildings, which, until recently, stood on the land, that is to say, the defendant, on the other hand; and that the judgment of the Court ought to be just the same as it would have been, if the ejectment had been brought to recover any other piece of land, which had never been called "Fazendary ground" at all, and the same evidence had been adduced as in the present case." It will thus be seen that his Lordship attached a wider meaning to the term "Fazendar" in Fazendari tenure than the one attached to the same word by Chief Justice Perry. The learned judge was of opinion that it was impossible to infer from the evidence, that those, whom the defendant represented, were merely tenants from year to year, and that the owners of the superstructure had not an interest in fee simple in the land on which it stood, and, that the rent paid was in truth a ground rent and not a quit rent. As to the interest or term of the tenant in the land on which the houses stood, the learned judge observed:—"we have already seen that the structures themselves belonged to the tenant, and he was at liberty to pull them down and carry them away whenever he pleased; a right which has in fact been exercised by the defendant. Where a house has been standing for several generations, it is of course impossible to shew the precise terms of the agreement under which it was built, unless they are preserved by a written instrument, and the most we can do is to draw an inference from the acts of the parties interested, with the assistance of evidence of the general understanding (if such there be) in the neighbourhood as to the rights of parties under similar circumstances, and we had a great body of evidence in this case, tending to shew that a general understanding, which has acquired the force of a custom, has been established in Bombay, that the Fazendar has a right, in the language of most of the witnesses, "to be satisfied", by a payment; of money, a present of shawls, turbans, or other valuables or an increase of rent, for his consent to the substantial repairing or rebuilding of the houses standing upon his land. That the tenants must "agree with the Fazendar," and indeed it is not disputed that he is entitled to something on these occasions; but the great question in dispute is this:—What is the alternative if the tenants cannot agree with the Fazendar, or if he chooses to withhold his consent to rebuild and the houses are pulled down by the owner of them? The inducement to the Fazendar to consent to rebuilding has never been fixed or determinate. It has depended upon a variety of circumstances. The learned judge then enumerated the same and continued, "all which tends to show that it is purely a matter of contract between the parties, which it would no longer be if the

Court were to hold that the Fazendar should be compelled to take what was awarded to him without having himself a voice in the matter. Considerable difficulties may arise from holding that the term of the tenant in the land is commensurate with the duration of the house; but I think there is much greater difficulty upon this evidence in coming to any other conclusion." The learned Judge dissented from the view taken by Perry C. J. and held that the interest of the defendant in the land was in respect of the houses which stood upon it, and that the houses having been removed, that interest had ceased and that the lessor of the plaintiff Dorabji Dady Suntook had consequently established his right to recover the piece of ground in question from the Lord Bishop of Bombay.

The next case is the case of Parmanandas Jivandas v. Ardeshir Framji (Suit No. 263 of 1883) decided by Farran J. in December 1886 and reported in the note to Yeshwant *v.* Keshavrao, 16 Bom. L. R. 723 = 39 Bom. 320. In this case, the plaintiff claimed to eject the defendant from, and to recover possession of, a piece of land at Bhundarwada Hill in the Island of Bombay admeasuring 675 square yards, and also damages from him on account of his wrongful occupation of the land. The defendant as to about 575 square yards of the land claimed by the plaintiff denied his right to eject him and claimed to hold the same from the plaintiff upon a Fazendari tenure which according to him, gave him the right to remain in possession of the land upon payment of a fixed annual rental so long as the plaintiff's title to be Bhandarwada Hill continued. The plaintiff was a holder under Government of the Bhundarwada Hill of which the pieces of land, the subject matter of the suit, formed part. By Indenture of Lease bearing date the 1st October 1794, the East India Company demised the Bhundarwada Hill to one W. H. Blackford for 99 years from the date of the lease at an annual rental and a premium or fine at the expiration of every 21 years of the term. The lease also contained a covenant for renewal thereof upon the expiration of the term and upon the application of the heirs, etc., on the same terms and conditions upon their paying to the lessor an additional fine or premium for such renewal and also further provided, that if the said lease should not be renewed, the lessors would pay the representatives of the lessee half the real value of the buildings and plantations which should then be on the land demised. There were 2 documents made in January and March 1850 respectively, the former of which went to show, that one Maneckbai had permission given to her by B and M, to build her house upon the ground, on the said hill for which she paid ground rent. The latter document of March 1850 was an Indenture of Lease between the said B and M and the said Maneckbai whereby a plot was leased out to her, as from the 1st of January 1850, as a monthly

tenant yielding and paying a certain rent and whereby the said Maneckbai covenanted at any time within one month next after notice in writing given to her, to quit and deliver up the demised premises to the lessors. There were the usual covenants against the lessee's assigning or sub-letting the demised premises without the lessor's consent in writing and also the usual right of re-entry for the lessor. This document was executed by Maneckbai, though there was no corresponding document executed by the lessor in her favour. In the year 1851, one Canji Chatoor became the assignee of the lease of the said hill and by a document, dated 8th December 1851, he purported to lease to the said Maneckbai 208 square yards of land of the said Hill at a certain monthly rent from the 1st January 1851. This lease also purported to have been executed by Maneckbai who paid rent from 1st January to 31st December 1851. The defendant also produced receipts for the ground rent for the years 1851 to 1854. The receipt for 1855 ran as follows:—*viz.*, "To amount of Fazendari rent of 247 square yards of ground situated at Bhundarwada Hill, Mazgaon for one year from 1st January to 31st December 1855, Rs. 30–14–0, Bombay, 1st January 1856 E. E. and contents received. Signed Canji Chatoor." In the year 1855, the form of the rent bill sent to Maneckbai was altered by the introduction of the word "Fazendari" before the word "rent" and the tenure of the land was altered from a yearly tenure into a monthly tenure. On these facts the Learned Judge was asked to decide the nature and incidents of the tenancy between the plaintiffs and the defendants. Great stress was laid upon the introduction of the word "Fazendari" in the rent bills sent to Maneckbai in the year 1855. Dealing with the question, whether the tenure of the land was altered by the introduction of the said word in the rent bills and holding that it was not, Farran J. observed at page 728 of the report: *"There remains the introduction of the word 'Fazendari' into the rent bills. The circumstances existing at the time this was done do not favour the contention that the tenure was then altered."*

The rent was continued at the same rate per annum. It is unlikely the lessor would have abandoned the advantages he possessed under the leases Exs. B and C without obtaining some corresponding advantage in the shape of an increased rental. Maneckbai's house had been then long completed. There was no change in ownership, why then a change of tenure ? The time when Manekbai commenced to build would presumbly be the time when she would have taken steps to strengthen her tenure and not when her house had been completed and she had no means of compelling her landlord to accede to her wishes.

At this time Canji Chatoor was granting leases in the same

form as Ex. B and apparently for building purposes. See Exts. H and I put in as specimens. One of these is a monthly and the other is a yearly tenancy. He has not shown to have leased any and upon a more permanent tenure. If such a very important, change was effected in 1855 in Maneckbai's tenure it must have been of design on Maneckbai's part, and at her request. Would she not have obtained some writing evidencing the change, and not rested content with a mere change of wording in her rent bills ?

The whole theory of a change of tenure rests therefore upon the introduction of the word "Fazendari" into the rent bills, and this leads to a consideration of what is the generally accepted meaning of that word. No evidence has been given upon this point. *My experience is that it is used with reference to tenants holding under a private landholder to indicate sometimes an indefeasible right to hold in perpetuity on payment of a small quit or ground rent and sometimes any kind of tenure agreed upon between the parties.*

His Lordship then referred to and cited with approval, the observations of Perry C.J. at p. 506 and Yardley J. at 508 with respect to the meaning of the word "Fazendari" and continued as follows :— "The word being thus ambiguous, it would be dangerous to assign to its introduction into a rent bill an indication that the parties thereby intended that a monthly tenancy should be converted into a perpetual one. In this case the framers of the rent bills produced by the defendant have varied the language in describing the rent paid by the holder of the land in question from time to time. The description is generally inaccurate. In my judgment the introduction of the word "Fazendari" into the rent bills may indicate a change in the person of the English writer who drew them out for Canji Chattoor or a desire on the part of that gentleman to have the title of Fazendar attached to his name just as much as a change in the tenure under which the land was held. *The title of Fazendar as it was used to describe the plaintiff in the case of Doe D. Dorabjee* v. *Bishop of Bombay was quite inapplicable to Canjee Chattoor who held under the leases from Government of which he was assignee.*

For these reasons I am unable to hold that there is any proof that Manekbai's tenure of the land she held was of a permanent character such as is described as a "Fazendari tenure" in the more limited sense."

It is important to note that in Parmanandas's case before Farran J. the land in question in the suit formed the subject matter of a lease granted by the East India Company on the 1st October 1794 for 99 years and that it contained a covenant for renewal of the said lease for a like term upon the same terms and conditions

save and except that the lessee was required to pay an additional fine or premium of Rs. 90 for such renewal. It is also important to note, that according to the decision of the learned Judge the Fazendari tenure is, so to say, divided into two classes, *viz.* (1) according to the strict and proper meaning, a tenure denoting tenants under a private landlord, to indicate sometimes "an indefeasile right to hold in perpetuity on payment of a small quit or ground rent" and secondly (2) "any kind of tenure agreed upon between the parties." In other words, a contractual tenure (a tenure loosely and properly so called) if we may be permitted to coin a new expression to convey the real meaning. It is also important to note, that the Learned Judge held in the case before him, that the title of Fazendar could not be used to describe Canji Chatoor who held under the Lease from Government, of which he was the assignee, as it fell under the latter class.

The law laid down by Perry C. J. in the Bishop of Bombay's case was also adopted by the Court of Appeal consisting of Bayley and Starling JJ. in Yeshwadabai *v.* Ramchandra Tukaram (1893) 18 Bom. 66. In this case in 1886, one Tukaram Moroji the defendant's father let the land in dispute in the suit to one Thacker Tricum Sewji Lowana in perpetuity, on Fazendari tenure for building purposes at an uniform rate of yearly rent. It was agreed that in the event of Government taking up the said land, the said Thacker Tricum Sewji and his successors or assigns should be entitled to receive the value of any buildings erected by him or them upon the land and that Tukaram Moroji should only be entitled to recover the value of the land. Thacker Tricum Sewji in pursuance of this agreement built a house on the land and paid as rent Rs. 102 per annum to Tukaram Moroji. He afterwards became insolvent and by diverse means assignments, the said house and land ultimately came into the possession of one Gopal Yeshwant who died intestate in February 1887, leaving him surviving, the plaintiffs, his widows. The said Gopal Yeshwant rebuilt the house and paid rent to the defendant until 1885. His widows the plaintiffs paid the rent to the Fazendar every year right upto 1890. On the 30th September 1891, the defendant gave notice to the plaintiffs calling on them to give up possession of the land which he alleged they held as monthly tenants. The plaintiffs declined to do so. The defendant then filed a suit in the Court of Small Causes in Bombay and on the 5th December 1891 obtained a decree for possession.

The plaintiffs now sued praying for an injunction restraining the defendant from executing the decree of the Small Causes Court and for a declaration that they were entitled to hold the land in perpetuity subject only to the payment of the aforesaid yearly rent and that

the defendant was not entitled to eject them so long as the said rent was paid. They also prayed that, in the event of its being held that they were not perpetual tenants, the defendant might be ordered to pay them Rs. 7,000 the value of the building standing on the land and Rs. 3,000 as damages for depreciation in the value of the property. The defendant denied that the plaintiffs were perpetual tenants and alleged that the rent was payable monthly, but had been often in arrear. Before the case had concluded, however, a document was produced which was said to be a counter-part of the agreement of letting made in 1866 by the defendant's father to the plaintiffs' predecessor It was not registered, and was, therefore, inadmissible in evidence. It was not tendered in evidence, but in cross-examination it was shown to the defendant who denied that it was a genuine document. The document was not made an exhibit in the case.

The Lower Court (Parsons J.) held that there was no evidence of the perpetual lease or of the right to hold subject to the payment of fixed rent as alleged by the plaintiffs, and that the defendant had a right to eject the plaintiffs.

The plaintiffs appealed. The appellate Court consisting of Bayley and Starling JJ. reversed the decree of the lower Court and ordered the defendant respondent to deliver and restore possession of the land and premises to the plaintiffs holding that the plaintiffs were not merely monthly tenants and that the defendant was not entitled by giving them a month's notice to quit to claim the property as his and that too without any compensation whatsoever. The Court held that the Court was, in the absence of any agreement or lease legally in existence, by reason of want of stamp or registration, entitled to look at and consider the evidence both oral and documentary and ascertain the terms of the tenancy by which the plaintiffs and their predecessors in title held the property and the plaintiffs having made out a prima facie case, without any agreement or lease, the Court came to the conclusion that the land was granted to Tricum Sewji for building purposes and even if it were originally not so, the fact that Tukaram Moroji (the landlord) did not object to Tricum Sewji, the tenant, erecting a building on the land for a period of 25 years and that he and his son accepted the rent during all that long period, the landlord would be and was precluded from ejecting the tenant without compensation. As to the tenure of the land, Bayley J. observed at p. 81 of the report, "In the case now before us, the receipts for rent put in evidence at the hearing are printed, and are headed Chinchpokli, in which district, according to Colonel Laughton's survey Map of 1872, the property in dispute is situated, and each of them is signed

by the respondent. We entertain little doubt that the plot of ground so granted was, as stated in the two indentures already referred to, Fazendari land, the tenure of which description of property is well known and is very common in this island, under which the Fazendar or landlord of the district or the part in which the land is situated is entitled to a fixed yearly rent, and as long as that is paid, the Fazendar tenant, who had undoubtedly an assignable and transferable interest, cannot, nor can his assignees or transferees be ejected by the Fazendar landlord. It would be a breach of contract and little short of a direct fraud on the part of this respondent, if he were to be allowed to treat the appellants as mere monthly tenants and by giving them a month's notice to quit, to claim the property and as he had done, to eject them, and that too, without compensation whatever."

It will be noticed that in the case just cited there was no document or written contract (legally in existence) which went to show the exact nature of the tenure between the parties. There was, however, uninterrupted payment of rent for a certain number of years by the plaintiffs and their predecessors in title who held the premises from the Fazendar which led the Court to the inference that the land had been let for building purposes on permanent Fazendari tenure. In other words, the absence of any written contract or document and the uninterrupted payment of rent were the grounds, upon which, the Court came to the said conclusion. But if there is a document, it is for the Court to construe the same and see what is the nature of the tenure, upon which the land is held by the tenant and if it is merely a permission or leave to build and does not indicate what the occupant's tenure really was or when there is no uninterrupted payment of rent, the Court cannot properly infer that the land is let out to the tenant for building purposes on permanent Fazendari tenure, but must find out from the document itself, the exact nature of the tenure and the terms and conditions, upon which, the land is held by the tenant. It may be that, in these cases, permission to build may have been given to the tenant by the landlord in view of a lease upon terms simultaneously or subsequently accepted or in the form common on the estate. This was so held, as we have seen, by Farran C. J. in Parmanandas's case and again by Farran C. J. and Starling J. in Shaik Husain *v.* Govardhandas Parmanandas (1895) 20 Bom. 1 which was also a suit for ejectment brought in 1894, by the executors of the will of Parmanandas Jivandas who was, as we have seen in Parmanandas's case, the assignee of a lease dated 1st October 1794 made between the East India Company and W. H. Blackford, which we have already set out before. In this case, the defendant contended, that he held the land on permanent Fazendari tenure, and produced a

document, dated 1848, by which his predecessor was given permission to build upon the land, on Fazendari tenure, at a small quit rent. The plaintiff, (landlord), however, produced the counter-parts of a subsequent lease to the same tenant (defendant's predecessor) dated 1851, which created a monthly tenancy, and of a latter one to the defendant himself, dated 1859, creating a yearly tenancy determinable on a month's notice, (both the leases not being assignable). It was under this latter document that this suit was brought. The defendant denied that he had executed this document and that he was merely a yearly tenant and contended that the documents were not duly proved, and that he was entitled to hold the land, subject only to the payment of rent. The lower Court (Parsons J.) held that these documents were admissible as ancient documents, and relying upon them passed a decree for the plaintiffs.

On appeal it was held by Farran C. J. and Starling J. confirming the decree, that having regard to the circumstances, the documents must be held proved and the plaintiff was entitled to recover possession of the land. It must be noted that the facts of this case were almost exactly similar to facts of Parmanandas Jivandas *v.* Ardeshir Framji decided by Farran J., which we have already cited and set out at length. Dealing with the question at issue, Farran C. J. delivering judgment observed at pp. 3 and 4 of the report as follows:—

" The question as to whether the execution of Ex. G and Ex. H has been satisfactorily proved, has also been raised before us.

It arises thus. Canji Chatur, the ancestor and predecessor in title of the plaintiff, purchased the Bhandarwara Hill in 1851. The hill is held on a ninety-nine years renewable lease from Government. It was conveyed to Canji Chatoor on the 23rd July 1851. At that time one Abdulla Shaikh Ismail was in occupation of a plot of land upon it. The nature of his occupation is not shown, but the defendant, who claims to be his nephew and heir, produced a document, dated the 22nd May 1848, in the following terms:— 'This is to certify that Abdulla Shaik Ismail has our permission to build his house upon our ground, part of Bhandarwara Hill, in Mazagaon, No. 19, of ground rent from which he pays to us.— (Signed) D. and M. Pestonji.'

It is contended by the appellant that this document shows that Abdulla was at that time a perpetual fazendari tenant of the land which he occupied. We do not think so. Exhibit No. 1 itself is a mere permission or license to build and does not indicate what the occupant's tenure really was. Had there been no other document in existence, and had the occupants showed an uninterrupted payment of rent ever since, the inference might fairly be drawn,

as it was drawn in Yeshwadabai *v.* Ramchandra 18 Bom. 66, that the land had then been let for building purposes on permanent Fazendari tenure; but if we find the tenant, a few years after its date, accepting a lease of a less permanent character, no such inference can fairly be drawn. The equally probable inference is that the permission was given in view of a lease upon the terms subsequently accepted, or in the form common on the estate. The existence of this document does not, therefore, throw doubt upon the genuineness of that to which we shall now refer."

The Court then referred to numerous documents and came to the conclusion that the lease dated 13th day of October 1851 and granted by Canji Chatoor to Abdool Shaik Ismail defendant's predecessor in title, created in effect a monthly tenancy to continue so long as the rent was paid, but determinable by the landlord on giving a month's notice and that the lease was in terms, not assignable. His Lordship, however, remarked, "It certainly does appear strange that Abdulla Shaik should have built upon the land expecting to get or having (for there is no evidence as to whether the buildiug upon the land was erected before or after the date of this lease) such an insecure tenure, but we cannot reject as unproved an ancient document simply because it is not a prudent act for a lessee to lay out money upon the tenure which it discloses. We are fully aware of the danger of treating old documents as established, merely because they are thirty years old and come from the proper custody."

The case of the Municipality of Bombay *v.* Shapurji Dinsha (1895) 20 Bom. 617 decided by Jardine and Ranade JJ. also illustrates the real nature of the Fazendari tenure. In this case a complaint was made to the Municipal Commissioner of Bombay of the filthy state of an oart or wadi in Mahim which was used for natural purposes by the residents in the wadi. The Commissioner in consequence required several of the owners of the huts to construct suitable privies, and on their failing to comply prosecuted them. It then appeared that these persons were tenants of a Fazendar, and that while they were owners of these huts, the land on which the huts stood, belonged to the Fazendar to whom they paid ground rent. None of these persons had any land appurtenant to the huts where they could build a privy, and under the circumstances it was impossible for them to carry out the orders of the Commissioner, unless they pulled down a part of the huts for the purpose of a privy. The Municipal Act prevented the Commissioner from destroying any portion of a permanent building for the improvement of an existing privy where none ever existed before. The charge against the tenants was, therefore, withdrawn, and the owner

of the wadi, the Fazendar himself, was called upon to provide a privy for the use of the tenants in the wadi. He did not do so and disputed his liability. On these facts the learned Magistrate Mr. Hamilton referred the following questions for the opinion of the High Court.

(1) Whether under the circumstances disclosed, the Fazendar (accused) is liable under s. 248, Bombay Act III of 1888, to provide a privy in this wadi for the use of the owners and occupiers of the huts which have no privies attached to them ?

(2) Does the word "Owner" in s. 248 include a Fazendar who receives the ground-rent of sites occupied by huts and who has no interest in the huts or the rents of the huts ? The word "Owner" is defined in s. 3(*m*) as the person who receives the rent of the premises.

It was argued for the Fazendar, that he was not the owner of the premises within the meaning of s. 248, so as to be liable to provide privy accommodation, that a Fazendar, as owner of the soil, was only entitled to a nominal quit-rent not liable to enhancement, that the huts built on the Fazendari land belonged to the tenants who lived there and realised the rents if they let those huts and that they were the real beneficial owners of the premises liable to provide the necessary accommodation. One of the grounds, upon which, the Fazendar's contention was put forward was that if a Fazendar were compelled to build a privy, he would have to alter the houses built on his land by his tenants, thereby rendering himself liable for trespass. On behalf of the Municipality, it was admitted that a Fazendar was not an owner, though he was getting a quit rent, but that the Fazendar being the owner of the whole oart, it would be no hardship to him, if he was compelled to provide privy accommodation. It was held by Jardine and Ranade JJ., that the Fazendar was not the person liable, as owner of the premises, to provide privy accommodation under s. 248 of the Bombay Municipal Act (III of 1888), the beneficial owner of the house built on the Fazendar's land being " the owner " within the meaning of the statutory provision.

The nature of the Fazendari tenure was discussed at some length by Beaman J., in the case of Yeshwant *v.* Keshavrao (1914) 16 Bom L. R. P. 252, where the learned Judge considered the effect of the decisions in the Bishop of Bombay's case decided by Perry C. J. and Parmanandas's case decided by Farran J. This was an ejectment suit in which the plaintiff represented the landlord under two agreements of 1859 and 1860 and the defendant represented the tenant under these agreements. The question for decision before the learned Judge was, whether the plaintiff was entitled at any time

to determine the tenancy which had been subsisting since the date of those agreements? The agreement dated 5th March 1859 ran as follows :—

"There is your Wadi by name Charni situate on the sea-shore, I have taken the land Fazendari (or on Fazendari or as Fazendar) being a portion of this wadi on the southern side for building a Cadjan house. On this land I shall build a house at my cost within Rs. 50. The ground rent is fixed at Rs. 6 per annum which I will continue to pay from year to year. I will pay the assessment, and if at any time you be in need of the ground appertaining to this house, I am to give the said ground to pay and you are to pay me Rs. 50 being a valuation thereof agreeably to what is written above."

At the time this agreement was entered into, it would appear from the report as if the intention of the tenant was only to build a Cadjan house of the value of only Rs. 50 and that he agreed to give up the ground whenever it was required by the landlord. In the following year that is, on the 22nd February, one Maneckji executed a lease in favour of one Gopinath in respect of certain land situate in the City of Bombay. The lease recited that the tenant had taken on Fazendari-land in the wadi for the purpose of building a Cadjan house thereon and provided inter alia as follows :—

" I shall build a house in the said wadi at my own cost. The Fazendari rent in respect thereof is fixed at Rs. 9 per annum which I will continue to pay to you from year to year. I will pay the assessment. I shall build a house on this land and live in it peacefully. I shall live there till the wadi remains in your possession. If the wadi ceases to be in your possession and if the land be required, you are to pay me the value of the said house, whatever the same may come to. Otherwise I shall pull down my house and remove it."

Gopinath in 1865 transferred his rights to the land in question to one Ramnath. In 1902, the heirs of Ramnath conveyed their rights to the plaintiff. In the meanwhile in 1871, Maneckji and his son Jayaram conveyed their rights under the Lease to one Atmaram, who transferred his rights in 1872 to Bhai Lakshmanji father of defendants 1, 2 and 3. The plaintiff filed the present suit on the 22nd January 1913, praying that the defendant may be ordered to quit and deliver possession of the land to him, he being ready to pay compensation to the defendants for their house or to allow them to remove the same. The defendants denied the lease, pleaded that the suit was barred by limitation and raised other defences. The learned Judge dismissed the plaintiff's suit for ejectment and decided in fovour of the defendants, holding on the

construction of the lease dated 22nd February 1860, that it was a lease in perpetuity. The learned Judge also held that the suit was barred by limitation. After discussing the law on the subject, the learned Judge said at page 256-257 of the report in this connection as follows:—

"Applying that reasoning to the terms of the present lease it is quite clear that there is nothing in it contradictory to the natural use and meaning of the words 'Fazendari tenure' which it contains. The landlord Gopal Danaji held the land in relation to the Government as a Fazendar, and, therefore, in perpetuity. He gives a portion of it to Manik Vithal on 'Fazendary tenure' that is to say as between him and Manik Vithal to the latter in perpetuity. I, therefore, have felt no difficulty whatever in constructing the document of 1860 as a lease in perpetuity."

It would appear as if the learned Judge based his decision upon the strength of the words "Fazendari tenure" which occurred in the lease and that he thought that the very use of the words "Fazendari tenure" used in a lease or a written agreement would go to show that the lease was always given in prepetuity according to the natural use and meaning of the words "Fazendari tenure."

The decision of the learned Judge was upheld by the Court of Appeal consisting of Scott C. J. and Daver J. It is reported in (1914) 39 Bom. 316 = 16 Bom. L. R. P. 720. Scott C. J. delivering judgment after stating the facts of the case at page 722 of the report, observed: "Now, we think that the landlord, whose possession is contemplated there must include both the landlord and his assigns and in the same way the tenant would include his assigns. Here we have a suit in which the landlord sues to eject according to the terms of the agreement, while he remains in possession of the wadi and the land is not required by anyone else. It appears to us that under the terms of the agreement, he has no right in such circumstances to eject the tenant." It must, however, be noted that though the learned Judges uphold the decision of the Court below, they expressly do so on the strict construction of the agreements before them. It is also to be noted that the learned Judges did not accept the view of the lower court with regard to the meaning of the words "Fazendari tenure" when they occurred in a written document embodying the contract between the parties. They entirely agreed in this connection with the remarks of Farran J. in Parmanandas Jivandas *v.* Ardeshir Framji. It was also held, that a mere non-payment of rent by a tenant, if the tenancy is not determined, does not give him a right to the property as against his landlord.

Thus the word "Fazendari" used in the agreement between a landlord and a tenant, even though it may indicate the nature of the rent, does not necessarily decide the nature of the tenure which must depend and does depend upon the agreement between the parties, when embodied in a written document.

The question of Fazendari tenures was recently discussed at some length and the important decisions in the Bishop of Bombay's case and in Parmanandas's case were considered and approved by Fawcett J. in Rahimtulla *v.* Hasanalli Alimahomed (1923) 25 Bom. L. R. P. 1192.

In this case by an agreement in writing the defendant agreed to sell to the plaintiff certain immovable property situate at Matharpakhadi in Bombay. The property sold was described in clause 1 as "Fazendari land" with the messuage, tenement or dwelling house standing thereon, situate, at Matharpakhadi with their appurtenances for an estate equivalent to an estate in fee simple in possession free from incumbrances. Clause 6 also provided that the vendor shall satisfy the purchaser, that the tenure of the land agreed to be sold was perpetual Fazendari at an yearly rent of Rs. 9 and that there is no sanad or surplus therein. During the course of investigation of the vendor's title, all that the defendant could show was that, in the earlier title-deeds, the property was described as Fazendari and there were Fazendari bills. The vendor also relied on the fact that the whole of Matharpakhadi was on perpetual Fazendari tenure and said to the plaintiff that if he had any doubt, he might satisfy himself by writing to the Fazendar. The plaintiff was not satisfied with the title offered and rescinded the contract under the power reserved to him and sued to recover the earnest money together with costs and expenses. At the trial a preliminary issue was raised, whether the tenure of the land agreed to be sold was perpetual Fazendari, subject only to a small annual rent. It appeared from the evidence that the land in question was admittedly situate at Matharpakhadi which forms part of what is known as the Mazagaon Estate, the history whereof was fortunately known from about the middle of 16th century. The Mazagaon estate became vested in the East India Co., and most of it was farmed out by the Collector of Bombay towards the end of the 18th century. It was leased out first to one Nesbit, then to his wife Mrs. Nesbit, thereafter to Sir Jamsetjee Jeejeebhoy and his sons and lastly to one Narayan Vasudev under document dated 9th April 1868. Thereafter a lease was given in 1837 for 99 years for a fixed annual rent by the Government to the executors of Narayan Vasudev and the title of the executors was finally vested

in Abaji Bhasker, a sister's son of Narayan Vasudev. The lease in favour of Narayan Vasudev included the right of re-entry to the Government which gave a right to possession and enjoyment of the demised premises "together will all the buildings and improvements thereon". The clause regarding the relinquishment of the property on the expiration of the lease also said that the land was to be given up "together with all erections and buildings then standing or being thereon." There was no provision for compensation for any improvements effected. So far as the lease itself went, there did not appear to be any restriction on the right of Government to re-enter and to also forfeit all sub-leases or sub-grants, provided the condition precedent giving Government the power of re-entry existed. It was contended that the right of resumption by the Government still subsisted and had not been relinquished and this contention was upheld by the learned Judge, on the ground, that the fact that ordinarily Government did not insist on their right to re-enter was not sufficient to show that the right had or has been either destroyed or relinquished, as there was no resolution or act of the Government, in which, they had bound themselves not to do so.

The main question which the learned Judge had to decide in the case was, whether the defendant had properly complied with cl. 6 of the agreement already set out and adduced sufficient and satisfactory proof that the tenure of the land agreed to be sold was perpetual fazendari subject only to the said small annual rent as agreed. After setting out the facts of the case, the learned Judge said, "the first consideration is as to the meaning to be attached to the word 'Fazendari'. After stating that it was not the first time that a question of this kind had come before the Court and after referring to the Bishop of Bombay's case and the dictum of Perry C. J. that the term 'Fazendari' usually denoted 'land not belonging to Government', the learned Judge explained the said dictum by adding that what the learned Chief Justice meant thereby was that the land was not subject to the ordinary liability of resumption and increase of assessment by Government, in other words, land that could be described as "freehold". The learned Judge then referred to the dictum of Yardley J. in the same case and observed that "he (Yardley J.) gave to the word 'Fazendari' a wider meaning and spoke of the Fazendar as being equivalent to an immediate landlord of the occupant, provided that the landlord was not Government." His Lordship then referred to the dictum of Farran J. in Parmanandas's case which, as we have seen, was approved by the Court of appeal in Yeshwant's case and which he also approved and followed by giving the same two meanings to the word "Fazendar" as Farran J. in Parmanandas's case.

The fact that the lease gave the Government the right of re-entry which put them into an advantageous position in regard to the occupants and which could be utilised by them to obtain an enhancement of assessment from the occupants as a condition of allowing them to remain in the occupation of their plots led the learned Judge to the conclusion that the word "Fazendari" used in Exhibit F meant Fazendari in the strict sense specified by Farran J. in Parmanandas's case, that is, "an indefeasible right to hold in perpetuity on payment of a small quit or ground rent" and that the word "Fazendari" could only be applied in the loose sense already pointed out before, if the conditions, under which the superior holder held the land, were such that that right was not established and that the defendants had failed to make out a marketable title as agreed. In coming to the said conclusion the learned Judge observed at p. 1206 of the report, "Though, therefore, I have considerable sympathy for the contention of Mr. Wadia, that, in practice, it is very improbable that the occupant of this plot will ever be disturbed by Government, yet the substantial fact remains that he is liable to such disturbance, and also, even if he is not disturbed, to being called upon to pay enhanced assessment; and in view of that liability it seems to me that the defendant has not satisfied the condition of clause 6 of Exhibit F that he shall show that the land agreed to be sold is 'perpetual Fazendari' at a small yearly rent."

In the case of Esubai *v.* Damodar Ishwardas (1891) 16 Bom. 552, a plot of land in the centre of the defendant's oart was granted to plaintiff's predecessor in title on Fazendari tenure for the purpose of building a dwelling and a hut was accordingly built thereon. No privy was attached or built with the hut, the occupants of the hut using the part or neighbouring oarts for natural purposes. The plaintiff bought the hut, knocked it down and proceeded to build a substantial dwelling with a privy on the site of the old hut. Defendant denied his right to build a privy or to have any right of way for sweepers to the said privy when built. The defendant also refused the use of the well water for the plaintiff's purposes. It was held by Sargent, C. J. and Telang J. that though there was an encroachment made by a tenant on the property of his landlord, it should not be presumed to have been made by the tenant absolutely for his own benefit and against the landlord, but should be deemed to be added to the tenure and form part thereof, and being thus added to the tenure and there being no evidence that the premises were originally occupied and there being nothing in the Fazendari tenure which forbade it, the plaintiff was entitled to devote the site in question for any purpose he thought proper and, therefore, to build a privy on it. It was also held that the suitable enjoyment

of the hut, when it was originally built, implied the use of a privy, whenever the occupants of the hut should think fit to build one and, therefore, the plaintiff was entitled to build a privy and consequently also to a way of necessity for a sweeper to have access to the privy when built.

(3) *Fazendari tenure and compensation :—*

The question whether in the case of Fazendari tenures, the tenant, when ejected, is entitled to compensation for the buildings erected upon the land depends upon the question, whether the land is held by the Fazendari tenant on Fazendari tenure in the sense, in which, the term is now ordinarily understood. If the tenant is merely an ordinary tenant with only a permission given by the landlord to build upon the land, by virtue of a lease simultaneously or subsequently accepted by the tenant or in the form common to the estate, the tenant, it would appear, is not entitled to make any claim for compensation. This was so held by Farran J. in Parmanandas Jeevandas *v.* Ardeshir Framji already cited by us before, where the learned Judge observed in his judgement (not reported) on the question under consideration as follows:—"As to the question whether the plaintiff is entitled to recover the premises from the defendant without making compensation to him for buildings erected upon the land, I do not know of any principle, under such circumstances as exist in this case which would justify me, in holding that the plaintiff is bound to take over the defendant's buildings at a valuation. It has not been argued before me that the defendant has a right to recover them nor has such a claim been made in the pleadings. The general facts of this case clearly resemble those which existed in Ramsden *v.* Dyson 1 H. L. 129 recognised in this Court, in Narayen Raghoji *v.* Bholagir Guru (1869) 6 Bom. H. C. R. A. C. J. 80. The fifth issue I, therefore, find for the plaintiffs." The same view was taken by the same learned Judge sitting in appeal with Starling J. in Shaikh Husain *v.* Goverdhandas Parmanandas (1895) 20 Bom. P. 1, where their lordships negatived the appellants' claim for compensation on the ground that a tenant who erects building on a demised land is not entitled to compensation on the termination of his tenancy. Dealing with the question at issue, his lordship Farran C. J. observed at pp. 6 and 7 of the report: "It remains to consider the defendant's claim for compensation. It was not put forward in the Court below, but it was urged in the memorandum of appeal and counsel for the respondent offers no objection to our dealing with it on the merits. In an unreported case of Parmanandas *v.* Ardeshir Framji, it was held by Farran J. in a case exactly similar to the present, arising out of a lease upon the same estate, that the evicted tenant was not entitled

to compensation for the buildings upon the land, and the same ruling was made by Starling J., in the case of Goverdhandas *v.* Rahim Rahimtulla also unreported. We think that these rulings were correct.

There is, as we have stated, no evidence to show whether the buildings upon the land, which are not denied to be of a substantial character, were erected before or after the date of Exhibit G. We know of no authority for holding that a tenant who erects buildings on a demised land is entitled to compensation on being evicted on the termination of his tenancy. His right to remove such buildings, which appears to be established by the cases of Narayan bin Raghoji *v.* Bholagir Guru Mangir 6 B. H. C. R., O. C. J. 80, (85) ; and Premji Jivan *v.* Haji Cassum P. J. (1895) 107 and is enacted by the Legislature in the Transfer of Property Act (IV of 1882) s. 108, seems to us to negative his claim to compensation. The law laid down in the judgment of the Court in the last cited case is this: "It is well-established law in England that if a stranger builds on the land of another, although believing it to be his own, the owner is entitled to recover the land with the building on it, unless there are special circumstances amounting to standing by, so as to induce the belief that the owner intends to forego his right or to an acquiescence in his building on the land. Ramsden *v.* Dyson (L. R. 1 H. L. 129 170) Plimmer *v.* Mayor, &c. of Wellington [9 App. Cas. 699 (710)] and see Dattatraya *v.* Shridhar, 17 Bom. 736. This is also the law in India, with the exception that the party building on the land of another is allowed to remove the building."

The same law, we think, is as applicable to a tenant building on his landlord's land during his tenancy as to a stranger building on the land of another. There are no special circumstances in the present case. The tenant must be taken to have known the terms of his lease as well as his landlord. And there is nothing to show that the landlord "created or encouraged any hope or expectation," in the mind of the tenant by his words or conduct. The granting of the lease in the terms of the Ex. G and Ex. H are, we think, quite inconsistent with such an idea. Such special circumstances, were found in the cases of Kunhammed *v.* Narayan 12 Mad. 320; Dattatraya *v.* Shridhar, 17 Bom. 736 and Yeshwadabai *v.* Ramchandra, 18 Bom. 66 and the Courts gave effect to them. The authorities are very fully considered in the last mentioned case."

But if the land let out is Fazendari, the Fazendari tenant, as was held by the Court of Appeal in Yeshodabai *v.* Ramchandra (1893 18 Bom. P. 66) has under the law undoubtedly an assignable and transferable interest and his assignees or transferees cannot be ejected by the Fazendar landlord by treating the Fazendar

tenant as a mere monthly tenant and by giving him a month's notice to quit and claim the property and that too without any compensation whatever, especially where the landlord has not objected to the buildings being erected by the tenant for a very long period and during that time has gone on receiving rent from the tenant. The court came to this conclusion in accordance with the English Law which secures to *bona fide* holders the value of the buildings erected or improvements made by them in the belief, that they had an estate in fee simple or other absolute estate, for the simple reason that the landlord is estopped by his permitting the tenant to erect pucca and substantial buildings on the land without any objection.

It may be pointed out that in Yeshwant *v.* Keshavrao (1914) 16 Bom. L. R. 252 decided by Beaman J. in the Lower Court and by Scott C. J. and Davar J. in appeal already cited by us before, the landlord was ready and wllling and actually offered to pay compensation to the defendants for their house or to allow them to remove the same.

(4) *Fazendari's rights on death of the occupant, intestate and without known heirs.*

There is one important question arising in connection with the Fazendar tenant which has been dealt by Mr. Dandekar in his book on land-tenures (1912) Ed. Vol. I, pp. 567-568 viz., whether the Fazendar or the Government has a right to the occupants' interests in the land in the case of the occupant dying intestate and without any known heirs. The question which arises in such a case is whether the land would lapse to the Government, subject no doubt to the liability to pay rent to the Fazendar or whether by reason of the determination of the occupants' interest on failure of heirs, the estate would revert to the Fazendar. Mr. Dandekar points out that in cases of double tenures such as Inams, Saranjams and Khoti, the occupants' interest (legally the inferior holder's) reverts to the Inamdar, Saranjamdar or the Khot as the case may be and opines with some hesitation in the absence of authority, that in the case of the Fazendari tenure also, the occupants' interest ought to revert to the Fazendar. We respectfully agree with the learned author, having regard to the fact, that the point has never arisen and been authoritatively decided, that it is impolitic to make any further observations, but submit having regard to the fact that the Fazendari landlord is entitled to the land, that he should naturally be entitled to the buildings erected thereon by the tenant in case of his death leaving no known heirs whatever and that the buildings thus erected should not lapse to the Government, even subject to the condition of their paying the agreed rent to the Fazendar, as the Government have no interest in the land.

(5) *Distinction between Fazendari tenures and leaseholds.*

There is a great difference between the Fazendari tenure and the tenure claimed under a lease. In the Fazendari tenure, the legal tie between the Fazendar and the occupant generally exists not by reason of any actual contract either oral or written, but is merely a customary one. In the case of leaseholds, the tie between the landlord and the tenant is necessarily contractual, either oral or written. In Fazendary tenures, the land is occupied by the occupant (the lessee) for building purposes only. In the case of leaseholds, it is not necessarily so. In the Fazendary tenure, the interest of the occupant is ordinarily perpetual, in the case of leaseholds, the interest of the lessee reverts to the lessor on the expiration of the lease or is determinable on the non-payment of the rent or the non-observance and non-performance of the covenants and conditions of the lease. The rights of the Fazendar and the occupant are inheritable and transferable, but in the case of leaseholds, though the rights of the lessor may be both inheritable and transferable, the rights of the lessee are generally governed by the terms of the contract beween the parties. In Fazendari tenure, the tenant has a permanent hereditary right to occupy the land on payment of the rent to the landlord which interest cannot be determined by the landlord even if the rent is not paid. The Fazendar is now entitled to no more interest in the land than merely to get the rent accrued due to him by the letting of the land to his tenant, the lessor's interest in the land is practically absolute, as he is practically the absolute owner of the land, being not only entitled to the payment of the rents, but to eject the tenant on the non-payment thereof or on the non-observance and non-performance of the covenants and conditions in the lease.

In the Fazendari tenure, the landlord has a right to enhance the rent even to an unlimited extent, in the absence of a contract express or implied or a custom proving the occupant's right to hold the land at a specified rent, in spite of the fact that the tenure of the occupant is perpetual and permanent. In the case of leaseholds, it does not need saying that the landlord being the absolute owner of the land is perfectly entitled to enhance the rent, in the absence of a contract to the contrary. In the case of leaseholds, the lessor has an interest in the land and a reversion. The lessor is entitled to enforce the lease against the lessee and even to forfeit it on the non-payment of the rent or the non-performance and non-observance of the other terms and conditions of the lease and to re-enter the premises under the right of re-entry usually reserved to the lessor under the lease, even in the case of a so-called perpetual lease. In the case of the Fazendari tenure, there is no right of re-entry and

no right reserved to Government to enhance the rent. Again the fazendari tenure is something not only different from the perpetual leasehold, but from a lease-hold perpetually renewable. In the latter case, certain acts are necessary to be done in order that the lease may be renewed and the terms of the lease originally fixed may be further prolonged. For instance, let us suppose that a lease has been granted by the Government, in the first instance, for a term of 99 years perpetually renewable for a like term, on the expiry of the original and renewed terms. Now suppose nobody comes forward to compel the Government to renew the lease, until the limitation period expires, the tenant, in such a case, would not be entitled to obtain a renewal of the lease, unless and until he complied with the terms of the lease and applied for such renewal and if he did not do so within the limitation period, his right to obtain a renewal of such lease from the Government would be barred by limitation. There is thus a great difference between a perpetual leasehold and perpetual Fazendary. There is also a difference between a perpetual leasehold and a leasehold perpetually renewable. But the difference between the Fazendari tenure and a leashold perpetually renewable is still greater.

(6) *Summary* :—

To sum up the law on the subject of this tenure, the Fazendar so far as the Government is concerned is practically the absolute owner of the land paying a small nominal quit or ground rent which also is very often not paid and the Government seldom take any action against the Fazendar for its recovery in the case of non-payment. In some cases, however, the Fazendar holds the land from the Government under a lease either in perpetuity or for a certain number of years. In these cases, the lease is either perpetual or contains covenants for renewal in pepetuity, subject to the payment of a small quit or ground rent payable by the Fazendar to the Government. In such cases, two important rights seem to be reserved to the Government *viz.*, the right of resumption of possession of the land leased out to the Fazendar and the right to an increase of the assessment payable in respect of the land. In those cases there is no true Fazendari tenure as such but it is merely a leasehold. It is, as stated before, really a sub-tenure between a private proprietor called the Fazendar and his tenant in which he (the Fazendar) is practically the owner of the land having vast lands in his possession which he farms out for building purposes subject to the payment of a small quit rent to his tenants. The question then arises as to what is the nature of the tenure as between the Fazendar and his tenant. The answer depends on the question whether there is a writing or no writing. If there

is a writing, it governs the relationship between the parties, if there is no such writing, the owner of the houses *i. e.* the tenant gets, to use the words of Farran J. in Parmanandas's case, "an indefeasible right to hold the land and the buildings if any erected" thereon in perpetuity on payment of a small quit or ground rent; in other words, he is for all practical purposes the absolute and beneficial owner of the house or houses erected by him and the Fazendar is not entitled to eject him and get possession of the house or houses built upon the land, even if he pulls them down and attempts to rebuild or erect new buildings in their stead as we find in the Bishop of Bombay's case and if he (the owner of the house) fails to pay the Fazendari rent, the Fazendar's only remedy is to recover the rent and that for not more than 3 years, as his claim for any more rent is barred by time.

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The following is the list of authorities on Fazendari Tenures.

(1) Doe Dem Dorabji *v.* Bishop of Bombay. (1848) Perry O. C. 498.
(2) Parmananddas Jivandas *v.* Ardeshir Framji [Suit No. 263 of 1883 (1914) 16 Bom. L. R. 723 = 39 Bom. 320.]
(3) Esubai *v.* Damodar Ishwardas, (1891) 16 Bom. 552.
(4) Yeshwadabai *v.* Ramchandra Tukaram, (1893) 18 Bombay 66.
(5) Shaik Hoosein *v.* Goverdhandas Parmananddas (1895) 20 Bom. 1.
(6) Goverdhan *v.* Rahim Rahimtulla, referred to by Farran J in Shaik Hoosein *v.* Goverdhandas Parmananddas (1895) 20 Bom. 1, at p. 6.
(7) The Municipality of Bombay *v.* Shapurji Dinshaw (1895) 20 Bom. 617.
(8) Sarafali Tyabali *v.* Subraya Bateraya and Another. (1895) 20 Bom. 439.
(9) Yeshwant Vishnoo Nene *v.* Keshavrao Bhaiji, (1914) 16 Bom. L. R. 252 on appeal, (1914) 16 Bom. L. R.720 = 39 Bom. 316.
(10) Rahim Rahimtoola *v.* Husanali Alimahomed (1923) 25 Bom. L. R. 1192.
(11) Bombay City Land Revenue Act by D. R. Vaidya (1931) 2nd Edition, pp. 104 to 112.
(12) Gazetteer of the Bombay City and Island (1909) Vol. II, pp. 338 to 340.
(13) Land Tenures in the City of Bombay and in the Presidency. (1912) Edition Vol. I, pp. 567-569 by Dandekar.

A CRITIQUE OF THE PSYCHOLOGICAL MATERIAL OF YOGA-PRAXIS IN INDIAN PHILOSOPHY

Though the distinction between the inner and the outer is only a relative one, we can maintain that the western mind has almost always tried to approach things externally, the ideal of human society being a state wherein man has attained complete power over Nature and its forces. Some philosophers in the West have no doubt posited that the true ideal is not that of an increasing control over Nature, but of a progressive reconciliation with the powers thereof through Art. Still, however, the above proposition holds true on the whole, and if any one maintained that from an ultimate point of view a true external or objective approach would lead one finally to the inner centre of a thing, he might be reminded of what has now become a commonplace in Philosophy, that as all external approaches are dependent upon the analytic functioning of our intellect, they would always be asymptotic in their nature, nearing a line which they never actually meet.

Indian mind has maintained that the mastery over, and the final reconciliation with Nature were always there, provided man could approach and realise his Innermost Self. All efforts were directed to break through, not merely the outer crust of our peripheral selves, but what might be termed from an analogy drawn from Contemporary Atomic physics, that '*high-potential wall,*' which lies near the centre of our Self and within which lie entrenched all the binding and driving forces of our total being. We might say that the result of such intuitive reaches or *breaches* was a mystical Union with the Divine or Cosmic Consciousness, which bestowed increasing power over one's self and its surroundings. Accordingly Indian thinkers always looked upon physical sciences not as means to gain external mastery over outward Nature, but as helps to regain the mastery over one's self. But it would be a prejudice to take it for granted that their observations in any field were unscientific, simply because their motive of enquiry transcended the purely scientific point of

* Based on "*The Heyapaksha of Yoga,* or *Towards A Constructive Synthesis of Psychological Material in Indian Philosophy*" by P. V. Pathak, M. A., Baroda College, Chancellor's Medalist, and K. T. Telang Gold Medalist and Prizeman in Philosophy (1931), University of Bombay, with a Foreword by Sir S. Radhakrishnan. Published by the Author at the Aditya-Press, Raikhad, Ahmedabad. The book was originally presented as a thesis at the M. A. Examination (1931), University of Bombay.

view. This is clearly seen in the treatment of Psychology which would naturally appear to be confused and weird to the western mind, and this is a humble attempt to show that divested of the categories which would be helpful to one in practical guidance for spiritual advancement, the Psychological Material found scattered in Indian Philosophy is worthy of a scientific synthesis.

A clear distinction between the subject and object of experience is a necessary pre-requisite of any psychological thought; and the Indian mind from the earliest beginnings of philosophic thought was peculiarly enough in possession of an attitude that was pre-eminently psychological. Thus apart from cosmological reflections in the Ṛigvedic hymns, we find clear references to the concepts of Individual Self, and the third something. We read 'Kāma (desire) grew after tamas and that was the primal germ of Mind.' In the Upanishadic thought we meet with a more elaborate classification of the Jñānendriyas and the Karmendriyas with their respective stimuli and actions as in the doctrine of the "graspers" and the "overgraspers" (Bṛih. 3.2), or as in Kauśi 3-6.7, where the ten indriyas are definitely mentioned, greater stress being laid upon the Prajñā as the co-ordinating principle between different sense-experiences.

Metaphysical constructions differ in different schools, but they all of them are at one in defining the final goal of all philosophic thought as the union of the individual self with the Universal Soul or the Absolute Divine. In the Upanishads the metaphysical background is that of idealistic monism with its peculiar mystic position subsuming immanence as well as transcendence of the Universal Spirit. In the Sāṃkhya and the Yoga Systems, we meet with a spiritualistic pluralism, akin to that of McTaggart in our days, superimposed upon a sort of dualism between the Purusha and the Prakṛiti. In the Upanishads the Brahman is described at times as active, at times as a mere 'spectator of all time and existence'. The Sāṃkhya-Yoga Purusha is purely static, all the seeming dynamicity being the beginningless work of old Prakṛiti. In Jainism we come across a *via media,* in which the conception of Soul comes near the modern concept of a concrete universal; with unity in diversity, and permanence in change. The Buddhistic position in metaphysics at least, very often like Aristotle in his definitions of some of the moral virtues, left the golden mean or the middle path, which both of them preached so much, and posited absolute dynamism or pure flux, growing intenser in its flow as one passed on from matter to mind.

In spite of such metaphysical differences, all the schools met together in the general forum of the yogic practices. Patañjali's Yogadarśana is pre-eminently a psychological darśana. The practice of Yoga must have been as old as the Vedic times. We find

it in a much evolved state in the later Upanishads (Maitrā. etc.) and the Yogadarśana might be regarded as its comprehensive formulation. References to Yoga are strewn in every system of Indian Philosophy. (e. g. Nyāya : 4.2.38 ; 4.2.40 ; 4.2.42 ; 4.2.46 ; Vaiś : 5.2.16 ; Sāṃkhya Sūtra : 3.30-31-34 ; also in the Tattvārtha : 2.52, 9.1, 10.1, 6.9 etc. etc.,) According to Buddhism the flux is not Reality, for even though it denies the existence of a static Soul, the ultimate goal which the individual has to reach is absolute freedom from the phenomenal flux. Because of the final ideal state in the Nirvāṇa, Buddhism had to invoke the aid of a principle cardinally different from the seeming dynamic flow and it was the pure law of causality (not necessarily joined with the law of uniformity) under the governance of which the Bergsonian flux was brought in Buddhism.

The Yogic practices were calculated to take the functionings of mind to higher levels of attention, where its powers of intuition would be fully developed. We have a direct touch with Reality in sense-experience, and the problem of Yoga is to raise up this directness of experience from its sub-relational level to supra-relational heights of Prajñā or Intuition. In between these two levels, lie sandwiched the analytic and the relational functions of our so-called intellect. So far as the actual Yogic practices are concerned the disturbing influences of our intellect must have been noticed, and that is why in the Yogadarśana, it is laid down that along with the other modifications of the mind, a sādhaka would have to free himself necessarily from the workings of the Vikalpa-Vṛitti. The Vikalpa-process is not that of what ordinarily goes by the name of 'Imagination.' It is both a process of abstraction in thought and a relationing process. As the former, it breaks up an indivisible unity into a diversity, and in its latter capacity it strikes up a relation or a semblance of unity between things that have no real connection.

It is in the Yogadarśana that the Vikalpa-process is laid down as a specific modification of our mind, distinct from other modifications of Pramāṇa, Viparyaya, Nidrā and Smṛiti. Still if one were to look deeper the functionings of the Vikalpa-process lie at the root of almost every modification of our mind, except pure sense-experience —that nirvikalpa-pratyaksha, wherein, as we said, our mind comes in direct touch with Reality. The passage from the nirvikalpa to the savikalpa-pratyaksha is from sense-data to meaningful perception. The psychological development from indeterminate to determinate perception is recognised by almost all the schools of Indian thought. The nirvikalpa pratyaksha is very well defined in the Sāṃkhya-tattva-kaumudī, and the Sarvadarśana-saṅgraha. In Jainism the progress from sense-experience to perception is deli-

neated in the four stages called avagraha, īha, avāya and dhāraṇā. Buddhism distinguishes seventeen thought-moments, four of which lie below the manodvāra, a concept similar to that of 'the threshold of consciousness' met with in Western psychology. The seventeen thought-moments of Buddhism can very well be destributed over the four Jain stages. The definition of pratyaksha as given in the Nyāya seems to give the palm to determinate perception epistemologically ; still, however, the privacy of sense-experience is fully recognised when it is said to be avyapadeśyam. In the Yogadarśana, the sub-relational nirvikalpa-pratyaksha is not directly mentioned, but only the higher nirvikalpa or para-pratyaksha of the Yogi is dwelt upon. The nirvikalpa pratyaksha of the sense-level is met with in Miśra's Tīkā. When dealing with the avasthā-pariṇāma of our several senses, and also of mind as well as of other objects, the ancient Indian thinkers must have been gifted with a very keen insight into the dynamic flow of the outside changing world, and of our inner consciousness as well, for in the concept of the avasthā-pariṇāma, the points of views of both Bergson and Eddington are brought together, in that, what looks like the growing richness of the contents of consciousness when viewed from an inner *durational* point of view, becomes a mere avasthā-pariṇāma, when viewed externally or objectively according to which a thing loses its youth, and becomes older every moment. This is why Eddington says, " we all are clocks."

The process from indeterminate sense-experience to determinate perception could be only possible in the case of objects spatially spread out and enduring in time. But spoken words consist of a pure time-series, and as such they can never co-exist. Herein comes for the first time the old doctrine of Sphota which has a very great psychological significance. Each and every syllable as it is spoken has only a nebulous character with different possibilities of entering into several meanings, in conjunction with the letters that might follow. Each and every spoken letter leaves its saṃskāra, till at the end the several saṃskāras get modified mutually, and a definite meaning '*breaks*' upon the mind by a process which might be described in Bergsonian terms as "*contraction*". (Several passages of the Vyāsa Bhāshya come very near what Bergson has laid down in his ' Mind Energy ').

The greatest contribution which the ancient Indian thinkers made in the field of psychology was the definite recognition of dispositional masses and the relation between structure and function of mind. Every modification of mind leaves its specific saṃskāra, and in turn every particular vṛitti or modification is the product of past residual elements functioning in the present. Thus our mind works

always in a cyclic fashion, though the same vṛitti would never recur in its absolutely identical form. It is because of our old saṃskāras that sense-experience gathers meaning. Over and above such so-called apperceptional masses, cognitive, conative and affective dispositional masses too are recognised. In the functionings of all these masses, the cyclic law of the relation between a vṛitti and a saṃskāra holds good, and this cycle when analysed becomes bigger with the insertion of new links in the chain. According to the Sāṃkhya-Yoga the wheel of the world, which is the same as the total functioning of our mind, has six spokes which are increased to twelve in Buddhism. From dharma and adharma spring up sukha and duhkha, from these attachment and aversion, actuated with which a man does good or bad actions, from the corresponding values of which we come to dharma and adharma again. The living nexus of will which might either result in automatism due to habit of beginningless past, or which might bring up freedom to man in the final shape of liberation of soul, lies between the experience of pleasure and pain and that of attachment and aversion. Pleasure and pain are things that come to us from the universe, as fruits of our past actions, and we can have no control over them as events that come and go. For the workings of dharma and adharma are adṛishta, and this conception when applied to the functioning of our own mind means that dharmādharma are what might be termed non-presentational qualities of our mind which can never be objectified. But if man has no power over the events of happiness and misery, he certainly has power, with the help of which he would keep his mind free from attachment for one or aversion for the other. By such a dynamic attitude of mind a sādhaka would be lifted up to higher levels of attention, where he would enjoy greater freedom denied to ordinary mortals. The dispositional masses form the structure of our mind, which structure is of its own making. Mind functions through its past experiences but we cannot, as Pillsbury does, prove the continuity of self merely through this characteristic of mind to preserve all its past experiences. The mental structure is nothing material, but like any other material structure it has an inertia of its own which might stubbornly refuse to rise superior to itself in its functioning. The Yogic praxis consists in going from lower to higher levels of consciousness, while the structure of mind is necessarily recast in doing this. Thus yoga stands for freedom of mind as distinguished from its automatism which is the result of the Law of Circular Causality working at lower levels of mind. It is to develop perfect *plasticity* of mind as against the rigidity of its structure. To achieve this Yoga asks a subject to catch the mind in the moment of

its functioning which it does through its structure. In the ordinary activity of mind, those vṛittis which arise *automatically* from the bed of past structure and hence tend towards bondage have to be suppressed. Biology tells us that when a structure ceases to function, it gets atrophied. The same happens with mental structure too. If those vṛittis that come as expressions of a certain structure be suppressed, the underlying structure would sooner or later get atrophied and die out. The meaning of suppression here is not " repression ". Due to the Freudian school there has been no dearth of pseudo-psychological literature preaching against " repression " and asking men to run out their own nature. Such a running out would only mean strengthening of the undesirable structure.

A question can very well be asked here, that if the structure gets atrophied, the mind would cease to function, for in order to function a thing must necessarily have some sort of structure. But Yoga, when a sādhaka's mind ceases to function from its past saṃskāras, it is said to be on greatest heights. The activity of mind is something quite different from any other activity that has to express itself through a product of some past material. The above-mentioned law of circular causality which chains down the mind to its past, may be symbolically expressed thus. If the flow of mental states be represented as

$S_1\ S_2\ S_3\ S_4 \ldots\ldots\ldots S_n \ldots\ldots\ldots$ etc.........

a single state of consciousness would be a complex whole, a part of which is made up of all the saṃskāras of past experiences, while the other component would be the free active co-efficient of attention leaning towards the future. Any two terms of such an ego-series can only be equated thus :—

$S_n = A_n \{S_{n-1}\}, \ldots\ldots\ldots S_5 = A_5 \{S_{5-1}\},\ S_4 = A_4 \{S_3\}$ etc.

where $A_n \ldots\ldots\ldots A_5$, A_4 are the functional free coefficients of voluntary or non-voluntary attention making original contributions to the contents of the series by leaving behind their own specific residua. If attention be non-voluntary it gets determined by the bracketed quantity the fruitions of which turn up according to the Law of Karma. Now the sādhaka has to work directly upon these coefficients, and to bring them under control to such an extent that the link of bondage between these and the bracketed quantities containing the beginningless saṃskāras of the past is snapped; and his mind becomes purely a dynamic flow of psychic energy undetermined by its past, and functioning with absolute freedom. A. B. Keith is of opinion that " the conception of the rule of Karman leaves no room for freedom of will, and that if there is a series each of which is in relation of cause, effect, cause, and so on, then while it can be said that the series as a whole is uncaused,

it is equally clear that every single link in the chain is caused and without possibility of freedom." We are not concerned here with the ethical question of the freedom of the human will, but with the psychological question of the nature of consciousness. Keith's criticism is aimed at the Buddhistic conception of the flow of vīthi-chittas, atomic minds which seem to set up a semblance of continuous individuality, simply because the content of each and every atomic mind is carried forward as in a bank ledger to the next atomic mind. The above series can very well represent the Buddhistic tenet of atomic minds. But the active co-efficients are left out by Keith, and by such a process of amputation he arrives at determinism. But it is active attention itself which is capable of not merely giving a fresh orientation to the whole of the past, but of breaking away from it as well. The Dhyāna-praxis is calculated to work upon this non-presentational co-efficient of attention, and thus free the inner self.

And as the sādhaka progresses in this he firstly stumbles upon the conception of self as food; then self comes to him as the principle of prāṇa. At the third stage he identifies his self with his Manas, then with his Understanding (Vijñāna) till finally he arrives at the highest conception of self as Brahman full of Ānanda (Bliss). The four stages of the conception of self mean very nearly the same thing as the well-marked stages in the development of the concept of self as laid down by Dr. Ward. According to him, the vital sense, co-enaesthesis or somatic consciousness is the first stage, the second being the self as the body—the sensitive and the appetitive self. The third is the imagining or the desiring self, and the fourth comes the concept of self as a thinking and willing self—a person, while the fifth is the pure, ego or self. In such a short paper like the present one we cannot enter into full criticism of equating the several terms. The Self as food is Dr. Ward's body as self, while self as prāṇa is the somatic consciousness; and the ancient Indian thinkers were nearer truth in putting body first and prāṇa afterwards. According to Dr. Ward "the earliest and to the last a most important element in this presented self———is somatic consciousness.' Here we might maintain that the somatic consciousness might be earliest or earlier from the point of view of existence but not so from the view-point of knowledge, and as such prāṇa as self would come after the concept of self as body. The other terms can easily be equated *en bloc* without any change. The concept of self is no *focus imaginarius*. It is the centre from which radiate all the lines that go to sustain the several expressions of our peripheral selves which lie as if on a circumference.

Our total mental and psychic life is very often described by the simile of a wheel with many spokes. Descartes compares the Soul to a spider sitting at the centre of the web which is its own creation. In the Kauśitaki, Chhāndogya etc., we come across the same metaphor of the wheel.

Thus the Indian Philosophic thought though ancient is not old but ageless, and comes in some ways startlingly near our modern ways of thought. In a non-technical skeleton outline like the present one, it would not be possible to dwell upon the richness of the psychological material in Indian philosophy. In the concrete delineation of such a wonderful process as that of Yoga, we meet with many of the questions of modern psychology. The structure and function of mind; relation of sense-experience to analytic thought and intuition; nature of perception, memory, dream and sleep; the question of the levels of attention as it lies spread out in sleep becoming tense in Samādhi, till at its highest level it goes off into a mystic trance; the relation between sleep and trance; the transformation of the structure of our mind through Yogic practices; a definite recognition of dispositional masses, and of the levels of subconscious mind corresponding to the levels of attention lying above the threshold of consciousness; a clear acceptance of the distinction between the presentational and the non-presentational character of some mental functions; enquiry into the relation between perceptions, its affective tone and conation; a definite theory setting up a co-relation between instincts and emotions; the problem of will; the nature of contact between mind and the outside world through senses; and the dynamic nature of mind are the principal topics of enduring psychological interest among others dwelt upon in the book, viewed critically and comparatively from the point of view of western authorities on psychology such as Prof. Wm. James, Prof. Stout, Dr. Ward, Wm. McDougall, H. Bergson, Pillsbury, Mrs. Rhys Davids, and other writers on Indian and Western Philosophy.

P. V. PATHAK

THE FINITE AND THE INFINITE

The Self as a thing of development and struggles felt in its Being can only be felt in our thoughts about imperfections, and such thoughts are never possible, unless we get opportunities to contrast the Not-yet with now or the now with the past. The capacity to remember the past and anticipate the future is our own. The Self then stretches beyond the narrow limits of the sensible present as the concept of Not-yet lies at the very core of self-development; the Self is always finite. The nature of thought is such that it cannot cease to disown its tendency of pushing questions to infinite regress. What the nature of the Finite and the Infinite would be possibly like, is more conveniently explained by reference to the notions of infinite vastness and Eternity, our particular experiences of space limiting a figure, and duration governing change in our life history. The difficulty arises in realising the exact nature of their relation.

The Self is always finite, because the conception of it lies at the core of Self-development.

The earliest awareness of our Being is felt in its vastness of totality, the unending Infinitude or wholeness of form; but this totality is not felt in its regular unity. This is especially handed over to the spiritual activity of mind; which means that the manifestation of the Ultimate Nature of Reality lies in its unity and belongs to the spiritual field.

In matters of experience the spatial type of unity is a condition of its further development. When we conceive, perceive or imagine any particular extension we think of it as an inseparable portion of the one all embracing space. Objects or their experiences are interpreted with the help of such categories or forms of unity. Our spatial experiences deserve closer observation. Śaṁkara too while trying to explain the nature of the Absolute or the Ultimate Reality resorted to spatial and temporal analogy. The relation of Reality and Appearance or the Infinite and the Finite has been compared by him to the analogy of the portion of space enclosed by a pot whose termination is a boundary in which it meets space beyond it. Further, whenever we think of two extensions which are separate in the sense of not meeting in a common boundary we think of them as

The temporal and spatial experiences are useful in understanding the relation of the Finite and the Infinite.

mediately connected by some intervening stretch of space. Again the fourth or the Turiya state of consciousness as not involving Becoming or change is the Ultimate Reality as contrasted with the other three states of consciousness. All this is to show that spatial and temporal experiences are highly useful in understanding the nature of the Finite and the Infinite.

Limit and change do not negate Reality but they make it rather definite for us.

External objects of experience become understandable when they are brought under the categories of Understanding. Without any such unity they become dispersed and acquire no meaning for man. However the notion of limit in any figure and the notion of change in a stream of consciousness are both positive. In all experiences of details, what is encountered is the positive nature of Reality. Limit and change do not negate Reality but they make it definte and positive for us. There is nothing in the universe, be it limited or changing, which can be said to be temporarily Real and ultimately unreal at one and the same time. What is in its limitation Real is positively Real while what is Real apart from limitation is also positively Real.

The Infinite is positive.

Both the Finite and the Infinite are thus positive. Turning again to the notions of infinite Space and Time, let us consider what the notion of the Infinite implies. Infinite means not limited. If the notion of limit is taken to be positive Infinite would mean absence of something which is positive and in this sense it will be taken as negative. But psychologically speaking the notions of absolute void or permanence are not possible without details arising for explanation; one can affirm that the Infinite is both positive and negative though not at one and the same time or in one and the same sense.

There is a tendency to consider the Infinite as the ground of the Finite in the sense that perfection is the ground of imperfection.

But sometimes the Infinite is considered as the ground of the Finite in the sense that perfection is the ground of imperfection. Because the Infinite is looked upon as the continuous wholeness and the Finite is viewed in its limitations, the former is considered perfect while the latter as imperfect. Perfection here means one harmonious whole; which imperfection lacks in Being. However the notions of perfection and imperfection refer to the fields of activity. An expert chemist is perfect in his own sphere of activity while an expert astronomer is perfect in his own field. Imperfection in such cases might refer to the individual fields of activity. Every field has its Supreme Law of Being for the realisation of which its particulars strive. Failure to adjust means imperfection. Even the

various fields of activity are in co-ordination to one another and the Ultimate Principle which guides and controls them marks them as more or less imperfect to the extent to which they succeed in obeying the Supreme Government. The Ultimate Principle rules supreme and is infinite and there is a tendency to consider the Infinite as the ground of the Finite. The Infinite is the ground because of which the whole system of universe becomes explicable.

But this is the process in Reality for Reality and by Reality. What about its comprehension? How is it related to Thought?

Intellectually speaking contradicting phenomena are finite.

Now in thought compatibles are assimilated while non-compatibles are reformed if they should be absorbed in its unity. The notions of Being and Becoming are contradictories. The phenomena of the empirical world are ever changing; they become what they are not. They contradict themselves. Thought-activity in such cases has ultimate true character and whatever the phase of its comprehension may be, it is not self-sufficient and self-explanatory; hence the contradictory is the Finite. The ultimate ground of these contradictions needs be such that it is not finite but infinite as not possessing any of the characteristics which determine the Finite. For the sufficient reason of the phenomenal world of change, the Infinite is a postulate of supreme intuitive truth.

With all that the transcendence of the Infinite does not negate its immanence. The Law of Contradiction is pervaded by the Law

The Law of Contradiction is pervaded by the Law of Sufficient Reason.

of Sufficient Reason which determines its application and verifies its truth by finding sufficient reason for everything in the Infinite alone. It is this, which specifies proper values. The contradictories become compatibles and the Finite is enabled to manifest its reality in such integrations.

One touch of the Ideal lends value to the Actual. The Actual which is haphazard cannot be consolidated in the Ideal Unity, as long

Morally speaking the relation of the Finite and the Infinite is just conceived of as the relation of the Actual and the Ideal.

as it is in its valueless condition. It is neither good nor desirable. But when the desultory condition attains to the uniformity of character, when the assertion of the Ideal Being is recognised and felt, the actual state of Being is said to be properly guided. This does not imply that the Actual coincides with the Ideal. Far from it. The more the governance of the Ideal the more the extension of Becoming. Bliss being realised in this process, the consciousness of progress is most vital and has its natural flow. It becomes most desirable for life itself, and in the responsibility of Self to the Ideal, the moral Being of selfhood receives the vision of

the Infinite. The Finitude of the Actual Being lies in its impulsive nature while the Infinitude of the Ideal Being lies in its uniformity. The irregularities or defects are washed away by the uniformity. With all that the very nature of the Finite is to become while it is in the nature of the Ideal to be always all pervading and all good. The Ideal may vary from person to person but this is not variation in its nature. It does not become manifold though it has infinite manifestations. It may be said to be many in this sense only. The Ideal does not change its real nature nor does it cease to guide and control in any of its manifestations. For the Finite the Ideal is different in different respects, but everything is uniformly governed by it, which means that it is characterised by its unity. The relation of the Finite and the Infinite is moral as conceived in the relation of the Actual and the Ideal.

Metaphysical consideration.

Metaphysically speaking the Infinite is Real while the Finite is unreal; but such a conception depends more or less on the nature of Reality as thought of by us. In this connection the theistic and pantheistic solutions are offered. In our awareness of the Real as mysterious something the question about its existence does not arise. Whether the Ultimate Reality is infinite or finite does not engage the attention of a pantheist, because it is considered to be the Immanent Being coextensive with the world. But that problem is all important for a theist for whom the Ultimate Reality or God who, though transcendent, is also the Creator of the world and enters into intimate relations with man and the world and is immanent by His personality, though by His Infinitude He far surpasses human persons. The pantheist believes in only one Supreme Ultimate Reality and as there is none other than that it cannot be contrasted with or brought into relationship with what we call the Finite.

Self-consciousness is a positive fact of immediate awareness and is non-contradictory. It is both of the nature of the Finite and the Infinite.

This Reality is uncontradictory metaphysical fact of immediate awareness. It is positive and real. Existence is identical with Reality. For one thing, none can ever deny the positive, real, immediate, and uncontradictory awareness of self-consciousness. If Existence is permanent beyond time, place etc., it is infinite by all means, and consequently Self-consciousness is infinite also. But if, on account of its varying details, it is to be termed finite, it is, then, both finite and infinite. Yet, as Reality is one, permanent existence, the Finite and the Infinite are both compatible and hence both are positive unless it can be proved that they contradict each other. This is to be done with the help of Reason or Intellect of course, and this has definite reference to self-conscious agents; even appeal to intuition involves

reference to us. There is a serious dilemma. From the side of Thought we see that both the Finite and the Infinite are not contradictory.

The relation of the Finite and the Infinite in exclusion and inclusion.

Confining our attention to the fact of Self-consciousness and taking it to be both finite and infinite, let us approach the problem of the Finite and the Infinite from the side of Reality. If the finite is conceived to be arrived at by the summation, that is to say, the Finite ad infinitum in the Infinite Supreme Reality, it has surely the positive character in its forward looking character and in this sense the Finite and the Infinite do not appear contradictory but are Real of course. Even if both are thought to be exclusive it must be seen what type of relation is involved. Whatever may be the tendency of thought, the Infinite is always conceived to be larger than the Finite and it is indeed positive; because it is only in that sense that the Finite is enlarged. So even in exclusion the Ultimate Reality or the Infinite remains to be positive. More often than not, the Finite is deemed to be negative but even in that case, in no type of relation the positive and the real character of the Infinite can be violated. Then the fact of Self-consciousness is the positive real fact and that even though it is infinite it is also finite in its details, both finite and infinite being compatible.

Apart from too much of abstract reasoning the nature of immanence and transcendence in theism and pantheism makes the whole matter rather concrete for discussion.

The nature of immanence and Transcendence in the Theism and Pantheism.

Transcendence means existence beyond the world and the ultimate transcendent Reality does not in the least involve anything pertaining to the unreal world. This Reality is impersonal or attributeless. But transcendence in the theistic sense is not impersonal; but the Ultimate Reality possesses all possible moral attributes which make Reality at least a person. These two are the special types of the relation by exclusion.

Immanence in the strict sense assumes that there is no room for God outside the world so that the immanent Being is co-extensive with the world which he dwells. This is rigid pantheism. For theism the ground is richer and God remains essentially what He is in even manifesting Himself in the Universe. These two are the types of the relation by inclusion.

When theists talk of God's immanence, let us see what they imply by it. They say that God is immanent in man and the universe as He sustains the life of all creatures. Clearly this does not necessarily imply His existence in them. The father sustains the life of his children but he is certainly not in them. Surely God is

apart from the world though by Him everything is sustained. God is immanent in man and stone in this sense only.

Whether it would be quite correct to assert that God is at once immanent and transcendent, is a question by itself. If God is co-extensive with the world, He cannot be said to transcend it, and if He definitely transcends it, He cannot be immanent in it. Transcendence excludes the co-extensive nature of God with the world; so for theism, when God is also spoken of as a transcendent Being in a way, He is conceived to be only a distinguishable part within the world itself. Such a consideration is depicted in the Aṃśāṃśibhāva of Reality in the system of Vallabha and in his doctrine of manifestation and non-manifestation.

Pantheism reduces itself automatically into intellectualism, because the worshipper has no real existence apart from the Divine. The individual is lost and with that the Supreme positive fact of self-consciousness is gone for good. The delight of the thinker in recognising his oneness with the Divine is speculative and does not at all imply religious ecstasy.

Although theism tries to recover human personality and reserves the individuality, yet it has been alleged that the relation of God and man remains artificial. God needs man and man needs God. But how? Certainly when God needs man, He does not need man as man needs man. To say that we live, move and have our being in Him, is expressive of the religious attitude of man from human side. Thus logically the transcendence of creative God is limited by something uncreated.

Yet religious experience is an event in life and as such it needs proper explanation. For theism immanence and transcendence are unified in God. How is this possible? God is perfect and we all strive after Him as unattainable perfection or the Ideal or the Infinite. In this sense no Being can exhaust the future while no Being can afford to neglect the past. Time, then, is a constituent of the very substance of Reality which is infinite. Now as God is immanent in the universe God is forward looking in His Divine manifestation and thus transcends all lower processes. God works for the benefit of imperfect finite man and therefore His Divine quality in time is beyond the human quality. The relation of give and take or the manifestation of Divine Personality is understandable on the simple analogy of Nature, wherein all lower processes are for the nutriment of the ultimate infinite process. What is nurtured is God, the infinite, the forward movement in time, the new emergent something. In this way one can reconcile immanence and transcendence.

Hence to say that the finite is negative and unreal is an unguaranteed and unwarranted statement. The soul and the world are real and at the same time Becoming can be predicated of them as well as we can predicate the same of the Infinite. From the positive fact of self-consciousness, the relation of the Finite and the Infinite is possible to affirm. The Infinite can safely be conceived of as Self-consciousness at least.

All moral and religious experiences are valid on such a theory; and wherever limitations and determinations are seen they are understood as manifesting the Ultimate Reality in its definiteness; nay, the Finite is realised in the Infinite and such relation is the supreme truth of self-realisation. Self-realisation by investigating truth in external nature, self-realisation by ritualistic performances, self-realisation by spiritual insight, self-realisation by self-renunciation or by moral discipline and self-realisation intellectually achieved are all different methods or processes whereby the Finite is taken within the Infinite who is incessant life, action and freedom; and it is in resigning the Finite self to the Infinite that the manifestation of God's Good Will or Grace is enjoyed and with this emergent personality man feels himself emancipated from the bondage of all that is lower in form and detrimental to the Eternal Infinite Evolution of Personality.

U. J. TRIVEDI

Reviews

The Principles of Logic. An Introductory Survey. By C. A MACE, M. A. Longmans, Green and Co. 1933. pp. xiii+388. *12s. 6d.* net.

Modern developments in logic have in the main taken three different directions. The Pragmatists, dissatisfied with the traditional logic for being too formal and for ignoring important practical differences, have attempted to psychologize logic with the result that facts and ideals have been confused. The Idealists have sought to correct the mechanical abstractness of formal logic by developing the epistemological and metaphysical significance of inference, or rather judgment, which to them is the fundamental logical act. And lastly the mathematical realists, ignoring the "epistemic" factor in inference, have converted logic into a purely formal and symbolic science, of the same type as mathematics but more general. Having some affinities with these last, but not falling definitely into their class, there is W. E. Johnson, who is not quite a realist because he regards logic as a science of thought and recognizes the importance of the epistemic factor, and is not quite an idealist because he confines himself to an analysis of the strictly logical process without following it up into its metaphysical implications.

Mr. C. A. Mace's *Principles of Logic,* which is the subject of this review, professes to be an introductory survey of contemporary logical studies and follows the school of Johnson rather than any other. To deal in detail with all the aspects of this useful work would take us further than we can afford to go in a brief review of this kind. To those who have been brought up in the traditional logic there is much here that is new and unfamiliar, and they should read the book for themselves to obtain an adequate idea of the subject-matter. The Aristotelian doctrine is dealt with in a few pages and the greater part of the work is occupied with modern developments. And almost throughout symbols are used which are likely to cause embarrassment at first to those not used to them, but, as the author points out, the symbols are never allowed to stand by themselves but are always explained in ordinary language.

The first important feature of the book is the analysis and classification of propositions. The traditional classification has been

found unsatisfactory by many logicians. Especially objectionable, for instance, is the division of propositions into Universal and Particular, with singular propositions classed as Universal. This division, the author tells us, should be replaced by the more fundamental division into General and Non-general or, as he calls them, Atomic propositions. Atomic propositions (which correspond roughly to the Singular propositions of the traditional scheme) are further divided (and so also General propositions) into Simple and Compound. Compound Atomic propositions are called Elementary. Or is it that all Atomic propositions are Elementary? The author's exposition here is rather difficult to follow and, particularly, his account of differences of order among propositions is confusing, if not confused.

The chapter on Compound Propositions, where the author explains their various kinds and the relations between them, is highly interesting, though perhaps a little difficult to a beginner, because the doctrine of inference is used without having been first explained. In the chapter on the Syllogism, which on the whole follows the traditional lines, there is a section on the Antilogism which deserves especial attention. The student of traditional logic who knows indirect reduction is not altogether unacquainted with the Antilogism. What is interesting in this section is the neat way in which the author shows how by means of antilogisms various moods in different figures may be seen to be equivalent and how all the moods of the fourth figure may be obtained.

The chapter on the General Theory of Deduction is in certain respects the most interesting in the book. It gives a brief account, and one not too difficult for a beginner, of the theory of pure logic contained in Whitehead and Russell's *Principia Mathematica.* It is necessarily impossible for me to give the reader a synopsis of this chapter. It must be read *in toto.* In a deductive system there are primitive principles and derivative principles deduced from them. The conditions to be satisfied by primitive principles are that they must be (i) mutually independent, (ii) necessary to the system, and (iii) sufficient for the system. The primitive principles of one system may be derivative in another. In the system of Whitehead and Russell the primary laws of thought, which are generally believed to be absolutely fundamental, are not primitive but derivative, the primary principles being seven in number, five of these being formal and two non-formal. The formal principles are:

(i) The Principle of Tautology: *If either p is true or p is true then p is true.*

(ii) The Principle of Addition: *If q is true then either p or q is true.*

(iii) The Principle of Permutation : *If either p or q is true then either q or p is true.*

(iv) The Principle of Association : *If either p is true or (q or r) is true then either q is true or (p or r) is true.*

(v) The Principle of Summation : *If is implies r then p or q implies p or r.*

These being purely formal principles, *i.e.*, hypothetical in character, they cannot yield categorical inferences. Hence the need of non-formal principles, which are two :

(i) The Principle of Deduction : What is implied by a true proposition is true.

(ii) The Principle of Substitution : Whatever can be asserted about *any* proposition can be asserted concerning any given proposition (Cf. this principle with the Aristotelian *dictum de omni*)

Given these seven principles the whole system which constitutes the logical basis of mathematics is obtained by rigorous deduction. Here it may be questioned whether the primary laws of thought are not necessarily implied in the principles. I for one think they are.

From the General Theory of Deduction we pass to the author's treatment of Induction. This is fairly comprehensive and deals with almost all the important aspects of the subject. Induction is defined so as to include not only what Mill considers to be induction proper but every generalization of whatever kind or degree. Thus inferences of particulars from particulars and inferences by analogy are also regarded as inductions. Following Johnson Mr. Mace distinguishes four types of inductions: Summary Induction (the Perfect Induction of Aristotle and the schoolmen) ; Intuitive Induction, in which the general principle is immediately seen ; Demonstrative Induction, in which the conclusion has the same degree of certainty as the premisses ; and Problematic Induction, in which the conclusion has less certainty than the premisses. Induction is also distinguished as direct and indirect. Direct induction is generalization of observed instances, and indirect induction is inference about one class from another class which includes it, or from another class which is co-ordinate with it. Mill's Methods of induction are shown to be methods of indirect induction and their practical utility to be very limited. Johnson's Figures of induction, which are based on degrees of variation in properties and not like Mill's Methods on presence or absence of instances, yield demonstrative conclusions provided certain conditions are realized.

Mr. Mace's conclusion after examining Mill's Methods and Johnson's Figures is that in induction it is impossible to have a conclusion that is both determinate and demonstrative.

I have been able to give only a very cursory account of what I consider to be the most important questions dealt with in the book under review, and I hope I have not misrepresented the author's meaning anywhere. The manner of exposition followed in the book, it must be confessed, is not very happy. Important points are mixed with unimportant ones and in several places the analysis is merely empirical and lacks finality. It would have been better if the author had not introduced "genuine logical problems" into his treatment of general principles. They only help to create confusion there and make it difficult for the reader to distinguish essentials from unessentials.

J. C. P. d'ANDRADE

Sabdaratnasamanvaya Kośa of King Sāhāji of Tanjore. Critically edited with an introduction and index by VITTHALRAM LALLURAM SHASTRI, Sanskrit Mahavidyalaya, Baroda. (Gaekwad's Oriental Series, Vol. LIX) Rs. 11-0-0.

This is a critical edition of the Sanskrit lexicon compiled by the Maratha Raja of Tanjore, Sahaji, and is a valuable addition to the Gaekwad's Oriental Series. It is based on three MSS. one belonging to the Oriental Institute and two to the Tanjore Library. Its royal author was a scholar of eminence and a great lover and patron of learning as can be seen from the extensive list of works published under his direct or indirect encouragement given in the foreword to the present volume by the general editor of the series. The literature on Sanskrit lexicography will be richer by the publication of this volume which will prove undoubtedly of interest to those interested in this special branch of learning.

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VOL. II JANUARY 1934 PART IV

STUDIES IN THE HISTORY OF GUJARAT

By

Prof. M. S. COMMISSARIAT, M. A., I. E. S.

Gujarat College, Ahmedabad

PART II—SHANTIDAS JAWAHARI, THE GREAT JAIN MAGNATE OF GUJARAT IN THE 17TH CENTURY.

(*Lectures delivered by the author, under the auspices of the University of Bombay, as the Thakkar Vassonji Madhavji Lectures for 1930–31*)

Part I appeared in Vol. II, Part I, of the Journal.

CHAPTER I

FAMILY AND CAREER OF SHANTIDAS JAWAHARI AND ACCOUNT OF HIS JAIN TEMPLE AT AHMADABAD

Jainism has produced in Gujarat in the course of centuries many distinguished religious guides and teachers whose names are held in high reverence by the community. But among its temporal magnates there is no name which can equal that of Shantidas Jawahari, who is said to have received, according to an old historical tradition, the title of Nagarsheth or 'Lord Mayor' of Ahmadabad in the early years of the seventeenth century. Without any connection with the official nobility of the Mughal Empire, Shantidas was able to exercise, by virtue of his business connections and his vast riches, an influence at the court of successive Mughal Emperors from the time of Jahangir to the accession of Aurangzeb which must have been envied by many an exalted *amir* or mansabdar of the Empire.[1]

Importance of Shantidas in the history of Gujarat.

According to tradition, the ancestors of Shantidas[2] were descended from the royal Rajput house of the Sisodias of Udaipur, it being not uncommon to find Rajputs adopting the Jain religion.[3] Shantidas was probably born during the last decade or two of the reign of Akbar, and the period of his active life was comprised during the reigns of Jahangir and Shah Jahan, for he died in the first or second year of the reign of Aurangzeb. His father

His ancestry.

1. Some popular legends are current in the capital of Gujarat about Shantidas, e.g. that he owed his rise to fame and fortune to the fact that during a visit on business to Surat, where he went to a temple to offer his prayers, he secured by accident the benefit of the Chintamani-*mantra* which had been prepared for another merchant bearing the same name; also that, during a visit to Jahangir's Court at Delhi, when the Emperor desired that he should be evaluated by the jewellers, Shantidas won the royal favour by the ingenious reply with which he solved the enigma. (See *Jain Aitihasic Rasmala*, ed. by Mohanlal D. Desai, pp. 2-7; also Maganlal Vakhatchand's *History of Ahmadabad*, in Gujarati, 1851, pp. 270-75). These stories are apocryphal and have no historical value.

2. The famous jeweller Shantidas, the son of Sahasrakirna, whose career is reviewed here, should be distinguished from a contemporary of the same name, Shantidas, the son of Mania, who is said to have given his patronage to a Jain work known as *Dharmasangrah* written by Manvijaya Upadhyaya in Samvat 1731 (A.D. 1674). The great jeweller died about 1659 or 1660 long before the date of this work. He was besides an Oswal while his namesake belonged to the Shrivamsa branch. (*Aitihasic Ras Sangrah*, Part III, 54 *n*).

3. *Jain Aitihasic Rasmala* (*Shri Shantidas Ras*, etc.), ed. by Mohanlal D. Desai, pp. 1, 49.

Sahasrakirna had two wives : by the elder was born Vardhaman, and the younger, whose name was Saubhagdevi, was the mother of Shantidas. During a long and eventful career Shantidas appears to have travelled extensively in India both for religious and for professional purposes, for he was not only one of the foremost jewellers and financiers of his day but as a devout Jain leader he considered it his duty to make frequent pilgrimages to the holy centres of Jainism.

The *Chintamani-prashasti* and its unique value, 1640.

An unpublished poem in Sanskrit verse, described as the *Chintamani-prashasti*, which was discovered by Muni Jinvijayaji in an old Jain work, helps to throw considerable light on the family of Shantidas and on various events in his career up to a certain date. The *prashasti*, judged by its contents, was evidently associated with the temple of Chintamani-Parshwanath, which was erected at Ahmadabad by Shantidas and his brother, and it supplies us with some exact dates both about the temple and the life of Shantidas. The colophon of the poem states that 'this song of praise of the temple of Chintamani-Parshwanath was written in 1697 S. on the second day, Friday, of the bright half of Pausha, by Vidyāsaubhagya, the pupil of the learned Satyasaubhagya (December 4, 1640 A.D.). The *prashasti* was thus evidently composed some fifteen years after the formal consecration of the great temple. We have also to note that no event in the career of the hero later than 1640 has been mentioned in this record.[1]

Events in the career of Shantidas upto 1640.

The earliest event referred to in the Chintamani poem is dated Samvat 1669 (A.D. 1612-13) when Shantidas consecrated an image of Mahasnath at the holy centre of Shatrunjaya. Five years later, in 1618, he became a Sanghpati and, in the company of a large number of *sadhus*, led a Jain pilgrimage to Siddhagiri where he spent large sums of money in charity. In 1621, jointly with his elder brother Vardhaman, he built the great temple in the suburb of Bibipur at Ahmadabad, and, four years later, in 1625, he consecrated the image of Parshwanath in this temple with the help of the learned scholar Vāchakendra. All these events are comprised during the reign of the Emperor Jahangir. On the accession of Shah Jahan to the throne, Shantidas received from the Emperor gifts of horses and elephants in 1628. Two years later, in 1630 (Samvat 1686), Shantidas used his great influence to secure for his religious head Muktisagar the dignity of *acharya* at the hands of the great Jain divine Vijayadevsuri. This ceremony took place at Ahmadabad in the temple of Mahavir Swami and Muktisagar now

He secures the *Suripad* for Muktisagar.

1. The *Chintamani-prashasti*, upon which some of the information about the family of Shantidas and about his temple has been based in this chapter, has not yet been published.

assumed the name of Rajsagarsuri by which he is familiarly known in the history of the Jain Church. This famous divine became the founder of a special *gaccha* in Gujarat known as the Sagargaccha and he counted Shantidas among his foremost supporters and followers at Ahmadabad. We are told that Vastupal, the nephew of the great jeweller, being the son of his brother Vardhaman, spent large sums of money in the celebration of the accession to the *suripad* of Muktisagar in the capital city of Gujarat.[1]

The wives and sons of Shantidas upto 1640.

The poem gives very full details of the ancestry of Shantidas, who is mentioned as belonging to the Ukesh family, and his descent is traced from a remote ancestor called Padma. His brother Vardhaman is said to have had six sons. Shantidas himself appears to have been a uxorious person, having married four wives, one after another, upto the year 1640. The names of these ladies are mentioned as well as of their respective sons, who were Panaji, Ratnaji, Kapurchand and Lakshmichand. We shall refer later to an important farman granted by Aurangzeb to this last-mentioned son who appears to have inherited the status and title of his father and to whose line belong all the future Nagarsheths of Ahmadabad.[2] Among several other factors that go to confirm the authenticity of the information conveyed by the *Chintamani-prashasti* is the reference to Azam Khan,[3] the great Viceroy of Gujarat, in one of its concluding verses. It is well known that this powerful grandee was Subahdar of the province from 1636-42 under Shah Jahan, and he was thus in power when the inscription was written in 1640. The verse referred to above reads as follows: 'Victory to Azam Khan, the righteous chief of Gujarat, at the mention of whose name the bodies of his enemies tremble with fear, their eyes roll up, and their hearts fail.'

Reference to Azam Khan, the Viceroy.

Shantidas builds a great temple at Ahmadabad, 1621.

The most important event in the early period of the career of Shantidas was no doubt the commencement in the year 1621 (Samvat 1678) of the magnificent Jain temple dedicated to Chintamani-Parshwanath in a suburb of Ahmadabad. The edifice must have been completed five years later in 1626, for in this year Shantidas is said to have

1. *Jain Aitihasic Gurjar Kavya-Sanchaya*, Ed. by Shriman Jinvijayaji, (Bhavnagar), p. 50.

2. For the ancestry and family of Shantidas see Appendix A at the end of this chapter.

3. Azam Khan's government of Gujarat is famous for the suppression of the turbulent Koli and Kathi tribes; for the construction of the great Castle at Ranpur; and for the building of the magnificent caravanserai near the Bhadra Towers at Ahmadabad.

formally installed therein the image of the Tirthankar. The temple is said to have been called Manatunga.[1] It was situated in the then flourishing suburb of Bibipur, which is now known as Saraspur, and the sacred monument was erected jointly by Shantidas and his elder brother Vardhaman. It is a matter for no small regret that while the great Muslim monuments of the fifteenth and sixteenth centuries at Ahmadabad still remain in almost perfect condition, this great Jain temple, built in the seventeenth century, has practically disappeared owing to reasons which we shall describe later.

Mandelslo's account of the temple, 1638.

Though Shantidas's temple at Saraspur is now no more, an elaborate account of the same has been, strangely enough, preserved in the work of a young German traveller in Gujarat, Albert de Mandelslo, who visited Ahmadabad in 1638, *i.e.*, within twelve years of the completion of the famous temple. He informs us that it was without dispute one of the noblest structures that could be seen in this city and adds that it was at the time of his visit new, 'for the Founder, who was a rich Banya merchant named Shantidas, was living in my time'. According to his description, the temple stood in the centre of a large court which was enclosed by a high stone wall. At its entrance there stood two elephants[2] of black marble 'done to the life' and upon one of them was placed the effigy of the builder. The temple building was vaulted and its walls adorned with human and animal figures. About it were the usual cloisters with cells each containing a marble statue in white or black representing the Tirthankars of the Jain Pantheon, though our traveller, like many others, thought them to be images of women, naked, sitting cross-legged![3]

Prince Aurangzeb converts the temple into a mosque, 1645.

In 1645, Prince Aurangzeb, then Viceroy of Gujarat under his father Shah Jahan, ordered the beautiful temple built by Shantidas at the suburb of Saraspur to be desecrated and it was converted into a mosque under the name of *Quvvat-ul-Islam* (the Might of Islam).[4] The meagre reference to this event in the *Mirat-i-Ahmadi* may be supplemented by a quotation from the French traveller M. de Thevenot, who visited Ahmadabad in 1666. He says:—

1. For the description of the temple given in the *Chintamani-prashasti* see Appendix B at the end of this chapter.

2. Their names are given as Vaghaji and Kalyanmal in the *Chintamani-prashasti*, verse 44.

3. 'Mandelslo's Travels into the East Indies,' translated by J. Davies, London, 1662, p. 30; See also Commissariat, M. S., *Mandelslo's Travels in Western India* (1931), pp. 23-25. For the full text of Mandelslo's account of the temple see Appendix C to this chapter.

4. *Mirat-i-Ahmadi*, Pers. Text, ed. by Syed Nawab Ali, Part 1.

"Ahmedabad being inhabited also by a great numbers of heathens, there are Pagods or idol-temples in it. That which was called the Pagod of Santidas was the chief, before Aurangzeb converted it into a mosque. When he performed that ceremony he caused a cow to be killed in the place, knowing very well that, after such an action, the gentiles, according to their law, could worship no more therein. All round the temple there is a cloister furnished with lovely cells, beautified with figures of marble in relief, representing naked women sitting after the oriental fashion. The inside roof of the mosque is pretty enough and the walls are full of the figures of men and beasts; but Aurangzeb, who hath always made a show of an affected devotion, which at length raised him to the throne, caused the noses of all these figures, which added a great deal of magnificence to that mosque, to be beat off."[1]

Thevenot's account of the desecration.

The famous French jeweller and traveller, M. Tavernier, who paid many visits to Ahmadabad in the course of his travels, is evidently referring to the Jain temple built by Shantidas when he says :—

Tavernier's reference to the Temple.

"There was a Pagoda in this place which the Muhammadans took possession of in order to turn it into a mosque. Before entering it you traverse three great courts paved with marble, and surrounded by galleries, and you are not allowed to place foot in the third without removing your shoes. The exterior of the mosque is ornamented with mosaic, the greater part of which consists of agates of different colours, obtained from the mountains of Cambay, only two days' journey from thence."[2]

It is not probable that so powerful a citizen and so devout a Jain as Shantidas would allow this insult offered even by an Imperial Prince to a monument built at such immense cost and dedicated to one of the Supreme Souls of the Jain religion to pass without making a representation to the Emperor. This may be premised from the grant of an Imperial farman, dated July 3, 1648, about three years after the Prince's viceroyalty, directing Ghairat Khan and other officials in Gujarat to restore the building to Shantidas and to make him complete restitution for all damage done. This most valuable historical document was in 1888 submitted by the then Nagarsheth Premabhai Hemabhai to the Superintendent of the Revenue Survey at Ahmadabad for

Shah Jahan restores the temple to Shantidas.

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1. *Travels of M. de Thevenot,* trans. by Lovell, London, 1687, Part III, p. 10.
2. J. B. Tavernier, *Travels in India,* Ed. by Ball, I, 72.

inspection.[1] But all traces of it were forgotten for about half a century until the author was able, after much labour, to locate it in the possession of Sheth Kasturbhai Manibhai, the grandson of Premabhai, at the end of 1932, in a long-neglected bundle containing several other valuable farmans.

Ghairat Khan as deputy for Dara in Gujarat.

This farman bears at its top the seal of Dara Shukoh and was granted on the 21st of Jumad-as-Sani of the Hijri year 1058 (July 3, 1648), being addressed to the officers of the Subah of Gujarat, and especially to Ghairat Khan, on whom special epithets of praise and regard are bestowed. The date is interesting, for we learn from the *Mirat-i-Ahmadi* that on this day the Emperor appointed his eldest son Dara as Viceroy of Gujarat in succession to Shaistah Khan who had been transferred.[2] But Dara's appointment was a nominal one, for he was allowed to remain at court and to carry on the government of his province by sending this Ghairat Khan as his *naib* or deputy to Ahmadabad. It is possible, therefore, that the farman was delivered to the latter on this day. As the farman has never been published before, we give below a full translation of the same :

Toghra (in golden ink) : Farman-i- Abul Muzaffar Shihab-ud-din Muhammad Sahib Kiran-i-Sani Shah Jahan Badshah-i-Ghazi.

Nishan : Nishan-i-Alishan Shahzada Buland Iqbal Muhammad Dara Shukoh.

Seal (in black) Muhammad Dara Shukoh *ibn* Shah Jahan Badshah Ghazi.

Shah Jahan's farman for the restoration of the temple, 3 July, 1648.

'Be it known to the governors, subahdars and mutasaddis, present and future, of the province of Gujarat, especially the one who has been worthy of various favours (*here follow various honorific epithets*), *viz.*, Ghairat Khan, who has been reliant on and gladdened by royal favours, that formerly, in respect of the temple of the leading person of the time (*zubdat-al-akran*), Satidas Jawahari, an exalted and blessed order had been issued to Umdat-ul-Mulk Shaistah Khan to this effect: Shahzada Sultan Aurangzeb Bahadur had constructed in that place some mihrabs (prayer-arches) and had given it the name of a mosque; and after that Mulla Abdul Hakim had represented to His Majesty that this building, by reason of its being the property of another person, could not be considered a mosque according to the inviolable Islamic law; a world-obeyed order, therefore,

1. *Jain Aitihasic Rasmala*, Ed. by Mohanlal D. Desai, Part I, 30.
2 *Mirat-i-Ahmadi*, Persian text, Ed. by Nawab Ali, Part I, 224.

obtained the honour of being issued that this building is the property of Satidas, and that because of the mihrab which the famous Prince had made in that place the above-mentioned person should not be harassed, and that the arch should be removed and the aforesaid building should be handed over to him.

'Now, at this time, the world-obeyed and illustrious order has been issued that the mihrab which the victorious and exalted Prince has constructed may be retained and a wall be built near the same as a screen between the temple and the mihrab. Hence it is ordained that, since his exalted Majesty has, as an act of favour, granted the aforesaid temple to Satidas, he should be in possession of it as before and he may worship there according to his creed in any way he likes, and no one should obstruct or trouble him; also that some of the Faqirs (beggars) who have made their abode in that place should be turned out, and Satidas should be relieved from the troubles and quarrels on their account.

'And since it has been represented to His Majesty that some of the Bohras have removed and carried away the materials of that temple, in the event of this being so, those materials should be got back from them and should be restored to the person referred to above (Satidas), and if the aforesaid materials have been used up, their price should be recovered from them and should be paid to Satidas.

'In this matter, this order should be considered extremely urgent and there should be no deviation from or disobedience to it. Written on the twenty-first of the month of Jumad-as-Sani in the year 1058 H. (July 3, 1648).'[1]

The temple is abandoned and has now disappeared.

This royal Farman may possibly have given some satisfaction to Shantidas who had built the temple, but by the Jain citizens of Ahmadabad the edifice must have been considered for ever desecrated so that, as Thevenot says, no worship therein was possible. Neither was it likely that the Muslims would utilise the building as a mosque after the Imperial orders. Under these circumstances there is no wonder that the monument fell gradually into decay and to-day it has practically disappeared, many of its stones and materials having been carted away and employed to build other structures.[1] There is little doubt that it cost its builder many lakhs of rupees at a time when the value of money was far higher than it is now. It is said to have resembled the beautiful Jain temple built by Sheth Hathising to the north of the Delhi

1. The reverse of this Farman contains the following brief endorsement: 'through the humblest of servants, Biharimal.'

2. Maganlal Vakhatchand's *History of Ahmadabad* (in Gujarati), 142-3.

gate at Ahmadabad about the middle of the nineteenth century at a cost of about twelve lakhs of rupees.

The images of this temple again set up in 1743.

From a later reference to this temple in the *Mirat-i-Ahmadi* we learn that, at the time of its conversion into a mosque by Sultan Aurangzeb, two of the marble images each weighing a hundred *man*, had been buried underground by Shantidas, though it was given out that these would be destroyed. In 1743, when the Emperor Mahammad Shah was on the throne of Delhi, and the Subah of Gujarat was given to Fakhrudin Khan, who governed through Jawanmard Khan as his deputy, these idols were again publicly set up at Ahmadabad. The historian says that 'marking the weakness of Islam and the decline of religious zeal' at this period, the descendants of Shantidas obtained, by means of a *douceur*, permission to bring these images on carts into the city where they were installed for public worship in an underground temple which had been in existence for a long time and where the Jains used in secret to carry on their worship owing to the fear of the Musalmans.[1]

Farman of 1629 about Jain temples and *poshals*.

We may now refer to an imperial Mughal farman granted to Shantidas by Shah Jahan in the early years of his reign in which the Emperor makes certain grants which are different in their nature from those Palitana grants which are the subject of several well-known farmans of a later date. This farman, now in the possession of the firm of Sheth Anandji Kalyanji, was written on the 21st May of the Ilahi month of Adar in the second year of the coronation, *i. e.*, in 1629–30. The document states that it had been brought to the notice of His Majesty that the temples of 'Chintaman' and 'Satrunja' and 'Sankhesara'[2] and 'Kesari'[3] were in existence long before the auspicious accession, and that there were three *poshals*[4] at Ahmadabad, four at Khambayat, one at Surat and one at Radhanpur in the possession of Shantidas. The order was, therefore, now issued to the effect that no one should put up at those places and houses for they had been granted to the Jains. The

1. *Mirat-i-Ahmadi*, Persian text, Ed. by Syed Nawab Ali, Part 2, p. 322.

2. Sankheshvar is situated near Panchasar in the district of Munjpur, 24 miles south of Radhanpur in North Gujarat. It is still a famous place of Jain pilgrimage, but the present temples are modern and raised on the site of old buildings that have quite disappeared. (*Bombay Gazetteer, V*, 347) The *Mirat-i-Ahmadi* describes this temple as 'Sankh Parasnath situated in pargana Munjpur Sarkar Patan'. (Nawab Ali and Seddon, *Suppt*, 139).

3. The temple of Kesharianath, sacred to Adinath or Rishabhdev, is situated in the village of Dhuleva, about 36 miles from the city of Udaipur in the state of the same name.

4. A *poshal* is a place where a Jain stays when keeping his *posha* vow, one of the four disciplinary vows of the Jains (cf. *Sanskrit, Uposhatha-shālā*).

farman proceeds to add that the Sevras, 'who recite the books Sagar and Sarogun' were permitted to remain in the Subah of Gujarat and they are enjoined not to fight among themselves but to engage themselves in prayers for the continuation of the State.[1]

APPENDIX A.

(i) THE ANCESTORS OF SHANTIDAS JAWAHARI.

According to the *Chintamani-prashasti*, Shantidas was born in 'the illustrious family of Ukesha, the birthplace of wealth'. His ancestry, as given in the *prashasti*, is as follows:

Padma = Padmadevi.
|
Kshmadhar = Jivani.
|
Sahalua (?) = Pati:(?)
|
Harapati = Punai.
|
Vachha ([2]) = Sagaradevi
|
Sahasrakirana
= (1) Kumari | = (2) Saubhagyadevi
Vardhaman Pradyotan = Viramdevi. | Shantidas = Rupam.
Panjika = Devaki.

(ii) FAMILIES OF VARDHAMAN AND OF SHANTIDAS (upto 1540).

(according to the *Chintamani-prashasti*).

Vardhaman
|
Vastupal | Raisingh | Chandrabhanu | Vijaya | Sundara | Kalyanmal.

Shantidas.
|
=(1) Rupa — Panaji
=(2) Kapur — Ratnaji (b. 1629)
=(3) Phula — Karpurchand (b. 1638)
=(4) Vachhi — Lakshmichand (b. 1640).

1. A photographic facsimile of this Farman (marked E), as well as those of several others, with imperfect and faulty translations, will be found in a small book entitled "Memorial from... Sheth Anandji Kalianji the accredited representatives of the Jain Community of India in reference to the grievances about their rights re: the Shatrunjaya Hill" (Bombay: *The Times Press*, 1925).

2. This name is confirmed by a couplet in other works. (See *Aitihasic Ras Sanghrah*, Part III, 53*n*).

Evidently, Manekchand, who is mentioned in the *Mirat-i-Ahmadi* and in some of the imperial farmans as the son of Shantidas, and who loaned, along with others, large sums of money to Prince Murad Bakhsh at Ahmadabad in 1658, was born after 1640 which is the date of the composition of the *Chintamani-prashasti*.

APPENDIX B.

DESCRIPTION OF THE TEMPLE OF SHANTIDAS GIVEN IN THE CHINTAMANI-PRASHASTI.

'In S. 1678 (A.D. 1621), Vardhaman and Shantidas, who had reached the zenith of their fortune, who had taken the religious vow along with the members of their family, who had been leading a very pure life, and who had heard that building temples led to good luck, built a magnificent temple in the suburb of Bibipur (verses 45-49). On the arches of the temple there were statues of females resembling celestial nymphs, while at the door of the temple there was the Panchapatra for protection. The lofty steps of the temple indicated the way for the heavenward march of the devotees. There were six halls in the temple called Meghanāda, Sinhanāda, Suryanāda, Ranga-rama, Khela and Gudhagotra. It had two turrets, four square temples around, and four underground shrines with idols of the Jina (verses 50-54).'[1]

APPENDIX C.

MANDELSLO'S ACCOUNT OF THE TEMPLE OF SHANTIDAS AT AHMADABAD IN 1638.

Visit to the temple of Shantidas, 1638.

'We returned into the city to see the principal mosque (temple) of the Benjans (Banyas) which without dispute is one of the noblest structures that can be seen. It was then new for the Founder, who was a rich Benjan merchant named Santidas, was living in my time. The mosque stands in the middle of a great court which is enclosed with a high wall of freestone, all about which there is a gallery much after the manner of our cloisters in monasteries, having also its seats or cells and in every cell a marble statue, white or black, representing a

1. The Sanskrit text of the *Chintamani-Prashasti*, which is corrupt, has been kindly rendered into English for the author by Prof. K. V. Abhayankar.

woman naked[1] sitting and having her legs lying cross under her according to the mode of the country. There were some had three statues, to wit, a great one between two little ones.

'At the entrance into the mosque there are two elephants of black marble done to the life, and upon one of them the effigy of the founder. The whole mosque is vaulted and the walls adorned with several figures of men and other living creatures. There was not anything within the mosque, save that at the further end of the structure there were three chapels or obscure places, divided one from the other by wooden rails, wherein might be seen statues of marble, like those we had seen in the cells, with this difference only that there was a lighted lamp before that which stood in the middle.

Black elephants in life size at the entrance.

'We saw there also one of their Priests who was then busy in receiving, from the hands of such as came thither to do their devotions, flowers wherewith he adorned his images; as also oil for the lamps which hung before the rails, and wheat and salt for the sacrifice, while he set the flowers about the statues. His mouth and nose were covered with a linen cloth, lest the impurity of his breath should profane the mystery, and coming ever and anon near the lamp he muttered over certain prayers and rubbed his hands up and down in the flame thereof as if he had washed them in the smoke, and sometimes stroked his face with them . . . But he continued this foolery so long that we had not the patience to see the end of it; so that we left him in the midst thereof to go and see the sepulchres which are the most remarkable rarities of the city.'[2]

The priests and the ceremonial performed in the temple.

1. Mandelslo, like M. de Thevenot later in 1666, mistakes the marble statues of the Jain Tirthankars in the cells for naked women sitting cross-legged. For the nature of these images see Commissariat, M. S., *Mandelslo's Travels in Western India*, (Oxford Press), 25n.

2. J. Albert de Mandelslo's *Travels into the Indies*, trans. by J. Davies, London, 1662, p. 30.

CHAPTER II

SHANTIDAS JAWAHARI AND THE IMPERIAL "PALITANA FARMANS."

Imperial Farmans obtained by Shantidas.

A number of Imperial Mughal farmans now in the possession of the firm (*pedhi*) of Sheth Anandji Kalyanji,[1] the accredited representatives of the Svetambar Jain community of India bear eloquent testimony not only to the great influence, of Shantidas at the Mughal court but also to the signal services which he was able to render to his co-religionists in Gujarat. These farmans are all authentic documents and have been carefully preserved during the past three hundred years. They are granted by Shah Jahan and his two sons Prince Murad Bakhsh and Aurangzeb and are addressed to the imperial officers of the Subah of Ahmadabad. The purport of all these farmans is to grant and to confirm to Shantidas the possession of the village (or *pargana*) of Palitana and the sacred hill of Shatrunjaya as Inam to be held by him for the benefit of the Jain community of which he was then the greatest leader and advocate. All these farmans, which we shall proceed to discuss in detail, have been beautifully reproduced in a small book[2] published by the firm of Anandji Kalyanji in connection with their famous disputes with the native state of Palitana.[3]

The earliest[4] of the Farmans relating to Palitana was issued towards the end of Shah Jahan's reign by Prince Murad Bakhsh when

1. Anandji Kalyanji is not the name of any person, but it is the fictitious name (signifying 'joy' and 'prosperity') of a firm which is managed by the leaders of the Jain Community in Western India. This body or firm has been established for many years in order to carry on all matters of business connected with the temples sacred to the Jain religion on the hill of Shatrunjya at Palitana. The principal authorities in the affairs of the firm are the descendants of Shantidas, the heads of the Nagarshet family at Ahmedabad. The President of the firm at present is Sheth Kasturbhai Lalbhai.

2. The book is entitled "Memorial (to Government) from the Managing Representatives of the firm of Sheth Anandji Kalyanji...in reference to their grievances about certain rights *Re*: the Shatrunjaya Hill" (Bombay: *The Times Press*, 1925).

3. My best thanks are due to Mr. Najib Ashraf Nadwi, M.A., who has made a special study of Mughal farmans, for his valuable help in the rendering of several of the "Shantidas Farmans" mentioned in this and the following chapter.

4. The farman is marked G and attested, along with all the others, by Mr. E. T. Candy who, as acting Judicial Assistant to the Political Agent in Kathiawar, delivered a well-known Judgment in the Palitana dispute on 28 December, 1875.

1. Prince Murad's grant of Palitana when Viceroy, Nov, 7. 1656.

he was viceroy of the province of Gujarat, and it is dated 29th Muharram in the 30th year of the 'auspicious' coronation of his father (7 November, 1656). The *toghra* at the head of the document bears the name of the Emperor with the *nishan* of Shahzada Sultan Muhammad Murad Bakhsh, along with the Prince's seal. The Farman is addressed to the officers, present and future, of the Sarkar of Sorath (Kathiavad) and declares that Shantidas, the Jeweller, the Chief of the Grandees, had represented that in the village (*mauza*) of Palitana, situated in the said sarkar, there was a temple of the Hindus called Shatrunja,[1] frequented by pilgrims. Therefore, the exalted order had been issued that the abovementioned village was granted as *Inam* to the said grandee. Knowing this, the officers should not interfere with him in any way. Though the grant is made expressly by name to Shantidas, it was apparently in trust, for it runs, 'so that the people of the adjoining places may come there for pilgrimage (*tirtha*) with peace of heart.' An interesting feature of this Farman is the fact that the reverse bears the words : 'Through the humblest of disciples Ali Naqi with his seal'. We know from history that this able and devoted officer was the diwan of the province of Gujarat during the period of Prince Murad Bakhsh's viceroyalty, and that he was shortly after this date destined to meet a violent death at Ahmadabad in 1657 at the hands of his master, when the hot-headed Prince killed him during a drunken frenzy.

2. Shah Jahan's Farman, dated June 21, 1657.

The above mentioned grant of the village of Palitana is confirmed and enlarged in the following year by an Imperial Farman[1] granted by the Emperor Shah Jahan and dated the 19th of the auspicious month of Ramazan in the 31st year of the most holy coronation, corresponding to 1067 Hijri (June 21, 1657). The *toghra* contains the full official titles of the Emperor and near it is a beautiful square seal of this ruler. The document states that the Pargana (*not* village) of Palitana, which is called Shatrunja, situated within the jurisdiction of the Sarkar of Sorath, a dependency of the Subah of Ahmadabad, has been given as *Jagir* to the happy and fortunate son Prince Muhammad Murad Baksh :

1. Shatrunjaya, the name by which the sacred hill of Palitana in Kathiwar is most commonly known, means, literally, the place of victory (*jaya*) over the enemies (*shatru*), which are *raga* (attachment to wordly things) and *dwesh* (hatred). The hill is considered the most sacred of the Jain places of pilgrimage (*tirthas*) in India, and is known by twenty-one other names, *e.g.*, Siddhāchal, Vimalgiri, Pundrikagiri, etc. Jain tradition holds this hill to be *shashvata* or eternal.

2. This is farman marked F reproduced in the *Memorial of Sheth Anandji Kalyanji* referred to above and discussed at p. 88 in Mr. Candy's Report.

the Prince being described under the most loving epithets, such as 'the comfort of the eyes of the state,' 'the young plant of the garden of the Khilafat', 'the fruit of the tree of grandeur', etc. The same pargana was by this Farman granted from the season of the autumn harvest as Inam for two lakhs of *dams* to Shantidas Jawahari by way of *altamgha.* This Farman, in continuation, enjoins upon the exalted children of high descent, the nobles and ministers, the mutsaddis of the Diwan's office, the jagirdars and karoris, that the holy and exalted order should be upheld and that the said pargana should be left to Shantidas and his lineal descendants from generation to generation. He was to be exempted from all dues and taxes and imposts in connection with this grant and they were not to demand from him every year a new sanad. It is difficult for us to offer any explanation of the discrepancy between the *village* of Palitana granted in Prince Murad's sanad and the *pargana* of the same name clearly mentioned in this and later farmans except on the assumption that the *Jagir* was transferred by the Emperor.

The injunctions in this sanad.

The Imperial farman next in chronological order is of great interest, not only in connection with Shantidas, but also because it supplies an important confirmation of the fact recorded by the Persian historians that, soon after the arrival of the news of Shah Jahan's serious illness, Prince Murad Bakhsh, then viceroy of Gujarat, proclaimed himself Badshah Ghazi or Emperor at Ahmadabad on 5th December 1657. From this date we may consider the rule of Shah Jahan to have come to an end in Gujarat and the Khutba was read in the name of the new ruler and coins were struck in the provincial capital and other towns. This Farman[1] is a confirmation to Shantidas of his rights by Murad Bakhsh not now as Prince but as the *de facto* Sovereign. The *toghra* bears his new titles, *viz.,* Abul Muzaffar Muravvaj-ud-din Muhammad Murad Bakhsh Shah Ghazi, and near it is his round lineal seal with the same words and the Hijri year 1068 (A.D. 1657-8). The date of the Farman is the 29th of the month of the blessed Ramazan in the first year of the auspicious coronation, *i. e.,* June 20, 1658. It recites that the pargana of Palitana, which is also called Shatrunja, has according to former sanads been conferred on Satidas Jawahari, and that this person has requested that a new exalted farman be granted to him. This request is granted, and the divans, vazirs, and the mutsaddis, etc., are instructed to regard the Pargana mentioned above as the *Inam* of Shantidas and not to hinder him in any way. An endorsement on the

3. Farman of Murad Bakhsh as Emperor, June 20, 1658.

He confirms the previous grants.

1. This is the farman marked H in the *Memorial of Sheth Anandji Kalyanji* and discussed at p. 89 in Mr. Candy's Report.

reverse of this Farman is interesting for it states that the Sanad was issued by Murad's son 'the humble disciple and sincere son Muhammad Izid Bakhsh Bahadur,' and bears a seal which reads 'Izid Bakhsh *ibn* Muhammad Murad Bakhsh Badshah Ghazi, first year of the coronation, 1068." The date on which the Farman was written (20 June 1658) shows that it was issued only a few days before Prince Murad was imprisoned by Aurangzeb at Mathura during the march of the two brothers from Agra to Delhi.

Shantidas and Aurangzeb.

Prince Murad Bakhsh was not destined to enjoy for many months the exalted title of Badshah Ghazi or Emperor which he had assumed at Ahmadabad at the end of 1657. After the combined armies of this Prince and Aurangzeb had signally defeated Dara at Samugarh, Murad's power was on the wane and on the march from Agra to Delhi he was inveigled into a trap by his brother and made a prisoner. These events made it again necessary for Shantidas to have the Imperial grants regarding the hill of Palitana confirmed by Aurangzeb who was now definitely emerging as the successful claimant for the throne of his father in the War of the Succession. Two royal farmans granted by the new sovereign to Shantidas have been preserved and are available for our study. The dates of these farmans, as well as other collateral evidence available in the *Mirat-i-Ahmadi*, make it clear that the great Jain magnate and financier had accompanied the camp of the confederate princes from the time of Murad's departure from Gujarat to join his brother in Central India to the date or dates when he obtained from the victorious Aurangzeb the confirmatory farman that he required and permission to return to his native city.

4. Aurangzeb's Farman granted to Shantidas, July 29, 1658.

With the rash Prince Murad now definitely out of the way, Aurangzeb arrived at Delhi in hot pursuit of Dara, and here in a plain near the city he went through his first quiet coronation ceremony on the first of Zil 'qadah H. 1068 (21 July, 1658). It is an interesting fact that the Farman now granted by Aurangzeb to Shantidas is dated the 9th of Zil'qadah, 1068 H. (July 29, 1658) *i. e.*, only eight days after his assumption of sovereignty. It is thus one of the earliest Farmans issued by this Emperor in a long reign of half a century. The legends on the seal and on the *toghra* of this document are significant for they are the same which Aurangzeb employed while he was Prince, the new seal and the new royal titles having not so soon come into use. The *toghra* reads: 'The illustrious royal order of Muhammad Aurangzeb Shah Bahadur Ghazi,' while the legend on the seal bears the same words with the addition of '*ibn* Saheb Kiran Sani.'

The text of Aurangzeb's Farman[1] is in most respects similar to that of the preceding ones which it was intended to confirm. Shantidas Jawahari had represented to the holy, auspicious and exalted presence that, according to the Farman of his late Majesty, 'the shelter of the Khilafat, the shadow of God, possessing the dignity of Solomon,' which was dated the 19th of the holy month of Ramazan in the 31st year of the coronation, the pargana of Palitana, also called Shatrunja, situated in the Sarkar of Sorath, a dependency of the Subah of Ahmadabad, had been given to this servant as Inam by way of *altamgha* for two lakhs of dams. He now desired an illustrious royal mandate to be issued from the Court of the Saltanat. Aurangzeb, therefore, again grants to Shantidas the said pargana as Inam to remain with his lineal descendants from generation to generation, and the usual instructions are given to the officials and mutsaddis of the Subah. The reverse of the Farman bears an endorsement to the effect that it was issued through Prince Muhammad, the eldest son of the new Emperor, and the Prince's seal affixed thereto reads : ' Muhammad Sultan Bahadur *bin* Muhammad Aurangzeb Shah Bahadur Ghazi, 1068 '.

The contents of this Farman.

Here then we shall stop in our survey and critical examination of the four Imperial Mughal farmans granted to Shantidas in connection with the possession of the village or the pargana of Palitana, 'also called Shatrunja'. One of these was granted by the Emperor Shah Jahan ; two more by Murad Bakhsh, once as Viceroy of Gujarat and again as *de facto* Emperor ; and the last one by Aurangzeb immediately after his informal coronation. Shantidas plays during this period the part of the trusted representative of the Jain community in the same way as the great *acharya* Hirvijaya Suri had done at an earlier date in the reign of Akbar. All these four farmans have been reproduced, with rather imperfect translations, in the book mentioned at the beginning of this chapter, which has been published by the Jain community as represented by Anandji Kalyanji. We propose to return to Shantidas in the next chapter and to discuss some very important and interesting Farmans, hitherto unknown, which the author has been fortunate to bring to light.

Summary of the 'Palitana Farmans.'

1. This is farman marked I reproduced in the *Memorial of Sheth Anandji Kalyanji* and discussed at pp. 89-90 in Mr. Candy's Report.

CHAPTER III

DISCOVERY OF NEW FARMANS ON SHANTIDAS: FINANCIAL LOANS MADE BY HIS FAMILY.

Discovery of new material on Shantidas.

The originals of the four Imperial Palitana farmans granted to Shantidas, which have been described in the preceding chapter, are preserved at Ahmadabad by the firm of Anandji Kalyanji. The author was given the facility of inspecting these some years ago by the courtesy of Sheth Kasturbhai Lalbhai, the President of this body. When a long cylindrical tin box was handed over to him from the safe as containing these well known Sanads, it was found, when opened, to the author's great surprise and no less delight, that the contents were something very different. Three original and absolutely new farmans, not hitherto known to exist, and not utilised by the Jains in their long legal disputes with the Palitana state, were thus by a strange accident brought to light. They are of the greatest historical value and give us further important information about the financial transactions between the Mughal rulers and Shantidas and his sons. Besides, one of them records the grant to Shantidas by Aurangzeb of the sacred Jain hills and temples at Girnar, Abu and Taranga which have not been referred to in any of the hitherto known farmans, all of which relate to Palitana. There are also interesting references to valuable help supplied by Shantidas and his firm to the Mughal armies on their marches. The present chapter will, therefore, be devoted to a detailed study of this absolutely fresh and genuine historical material. But we shall also incorporate such information as is given on the subject by the *Mirat-i-Ahmadi* and other sources, including a new farman granted by Aurangzeb to Lakhshmichand, the son of Shantidas, which is now in the possession of Sheth Kasturbhai Manibhai Nagarsheth, the lineal descendant of Shantidas Jawahari.

1. Murad's Farman about the loan secured at Ahmadabad.

The first of these newly discovered Farmans is granted by Murad Bakhsh as Emperor to Shantidas, and the date on which it was written, 22 June 1658, shows that the grant was made only four days before this ill-fated and rash Prince found himself suddenly a prisoner in the hands of his brother near Mathura during the march of their joint armies from Agra to Delhi in pursuit of Dara after the aged

Emperor Shah Jahan had been placed in confinement. Shantidas was, in all probability, in the camp when he received this grant. The farman is an order by Murad to his imperial representative in Ahmadabad to repay, from the revenues of certain specified parganas, the loan of five lakhs and fifty thousand rupees which had been secured by this Prince from Manekchand, the son of Shantidas, and others, on the eve of his departure from that city to join his brother in the War of the Succession. The following is a complete translation of Murad's farman:

Toghra : Farman of Abul Muzaffar Murawwaj-ud-din Muhammad Murad Bakhsh Badshah Ghazi.

Translation of this Farman, dated 22 June, 1658.

" Be it known to the shelter of the Vazirate, the deserver of favour and kindness, Haji Muhammad Quli, who has been honoured and elevated by boundless and exalted favours, that Satidas Sahu has been honoured with an auspicious audience by His Majesty, and, by virtue of the favours with which he is associated, this world-obeyed illustrious order, which demands obedience, is issued to the effect that the amount which has been borrowed from Manekchand, the son of the above-mentioned person, and his brothers, at the place of our accession Ahmadabad, as a loan for the government—which is the foundation of the world—and the details of which are described below, should be paid off from the revenues, for the kharif season of this year, of the parganas mentioned herewith.

" Since Manekchand has rendered meritorious service, and Satidas, by virtue of his fidelity and loyalty, has received the blessing of an audience, therefore the exalted order is repeated that he (Haji Muhammad Quli) should exert himself in this matter in such a way that the loan made by him and his brothers is soon repaid. Considering this as most urgent, he should act in accordance with the holy and exalted order. Written on the 1st of the month of Shawwal in the first year of the blessed accession (June 22, 1658)."

The reverse of this Farman bears the interesting remark: 'Issued through the humble disciple and sincere son Muhammad Izid Bakhsh Bahadur.' It also contains in *shikastah* script the details about the various ports and parganas from the revenues of which for the kharif harvest the loan advanced by Manekchand and others was to be repaid.

That this farman of Murad Bakhsh, about the repayment of the loan secured at Ahmadabad, recently brought to light in original, is an

authentic historical document, finds unexpected confirmation from the *Mirat-i-Ahmadi*. The author of this work, who had access to the original records in the office of the Diwan at Ahmadabad, reproduces the same farman in identical language, the only difference being that the officer to whom it is addressed is named as the *Khwajasara* Mutamad Khan. In introducing the document, the historian remarks that out of the total amount which Murad Bakhsh had raised from the inhabitants of Ahmadabad, 5,50,000 rupees were due to the sons and brothers of Satidas Jawahari who was a favourite of the court and known to the exalted Princes. He waited upon His Majesty 'the King of the World' (i. e. Prince Murad) after the defeat of Muhammad Dara Shukoh, and the Prince, only four days before his own imprisonment, sent this Farman with his own seal to Mutamad Khan for the repayment of the above-mentioned loan.[1]

The *Mirat-i-Ahmadi* reproduces this Farman.

The text of the farman as given in the *Mirat-i-Ahmadi* gives the details about the repayment of the loan of 5,50,000 rupees to Manekchand etc., from the revenues of the Kharif harvest, as follows:

Details about the repayment

From Surat,	1,50,000	rupees.
From Khambayat,	1,00,000	„
From pargana Petlad,	1,00,000	„
From pargana Dholka,	75,000	„
From pargana Bharuch,	50,000	„
From pargana Viramgam,	45,000	„
From Namaksar,	30,000	„ (Total 5,50,000 Rs.).

The Farman concludes thus: 'In accordance with the holy order it was decided that since Manekchand has always been rendering service, his loan should be repaid first and after that the other merchants should be paid, viz., Manekchand, 4 lakhs and 22 thousand; Rabidas (Rakhidas), the partner of Satidas, 40 thousand; Sanmal and others, 88,000.'

Three or four days after he had granted the above farman, Prince Murad Bakhsh, as a result of his own folly, found himself a prisoner with golden shackles on his feet in his brother's tent near Mathura. Shantidas must have realised that the sanad just secured for the repayment of the large loan given to this Prince was now hardly worth the paper on which it was inscribed unless it was confirmed by the victorious Aurangzeb. His efforts in this direction, for, he was actually travelling with the camp, proved successful, as may be seen from another of the new farmans recently brought to light, dated

Murad's imprisonment: Shantidas turns to Aurangzeb.

1. *Mirat-i-Ahmadi*, Ed. by Nawab Ali, Pers. text, Part I, 238-9.

10th August 1658, at which period Aurangzeb was probably encamped on the banks of the Satlaj on his march to Lahore in pursuit of Dara. This date is also important for another reason for on it Shantidas received another farman[1] from the same ruler granting him permission to leave the camp and to return to his native city of Ahmadabad. We shall give below a translation of the farman in connection with the repayment of the loan:

Toghra (in golden ink): The illustrious farman of Shah Muhammad Aurangzeb Bahadur Ghazi.

2. Aurangzeb's farman about the loan, 10 Aug., 1658.

'Be it known to the thrifty and favour-desiring Rahmat Khan, who has been honoured by the royal kindness, that the chief among the nobles, Satidas Jawahari—who has received the honour of the audience of his illustrious majesty, and who has been permitted, on this occasion of auspicious beginning and happy ending, to go from the court to his native place Ahmadabad—has brought, through the medium of those who stand at the foot of the throne, to our exalted and elevated notice that Prince Murad Bakhsh has taken at Ahmadabad (as a loan) the sum of five lakhs and fifty thousand rupees, of which amount four lakhs and sixty-two thousand rupees were from Manekchand the son and from Rakhidas the partner of the servant (Satidas) and eighty thousand from some of the relations of this humble person, according to the details written below, and this has been the cause of anxiety to the servant.

'Therefore, on account of our kindness and generosity we grant the sum of one lakh of rupees from the royal treasury to the said person, and in this connection an illustrious farman has been also issued to Shah Nawaz Khan[2] (the Subahdar)—the epitome of the family of the Prophet, the chief of the household of Ali, the pillar of the great Empire, the receiver of boundless favours, the centre of unlimited goodness, the elevated, the Khan.

'And, therefore, this world-obeyed and obedience-demanding order is also issued to you who deserve favour that, after satisfying

1. This farman is given by the author of the *Mirat-i-Ahmadi*, Persian text, Ed. by Syed Nawab Ali, Part I, 240-41.

2. Shah Nawaz Khan Safavi was the first Subahdar of Gujarat appointed by Aurangzeb after his informal coronation at Delhi. Rahmat Khan, to whom the Farman is addressed, was *diwan* of the province at this time. Shah Nawaz was father-in-law both to Prince Aurangzeb and to Prince Murad. His viceroyalty was a brief one, for he joined Dara when that Prince arrived at Ahmadabad during his flight through Cutch and the two together proceeded to Ajmir where this Prince was signally defeated at the battle of Deorai. Shah Nawaz Khan was killed by a cannon ball during this battle (March, 1659).

yourself about this loan of four lakhs and sixty-two thousand rupees made by his son and his partner, you should, with the concurrence of the above-mentioned Khan, give one lakh of rupees to the said person without any delay and hesitation so that he may, by making use of it, carry on his business and profit by it. This should be treated as urgent and considered peremptory. Written on the 21st of the month of Zil'qada, 1068 H. (August 10, 1658).

The next farman in point of strict chronology is interesting as well as unique in the fact that it was granted by Aurangzeb not to Shantidas but to his son Lakshmichand, and its original is at present in the possession of Sheth Kasturbhai Manibhai Nagarsheth. The date of the farman is 30 January 1659, when the Emperor was probably resting at Agra after his decisive victory over his brother Shuja at Khajwah (near Korah) in the first week of the same month. The following is a translation of this farman granted by Aurangzeb to Lakshmichand within six months of his accession. The victor in the Fratricidal War was anxious to win over to his side this powerful Jain family of Gujarat, especially as Dara, though in headlong flight, had not yet been captured.

3. Farman given to Lakshmichand, son of Shantidas. 30 Jan, 1659.

'In the name of God, the Compassionate and the Merciful.' (Seal) Abu'l Muzaffar Muhiuddin Muhammad Aurangzeb Badshah Alamgir Ghazi Bahadur.

'Be it known to the mutasaddis (administrators) both of the present and the future of the Subah of Ahmadabad who are hopeful of the royal favour, that Lakshmichand, the son of Satidas Jawahari, has recently submitted, through those who stand at the foot of the throne of the Khilafat, to the noblest, holiest and most exalted (majesty) that he has sums due from his gumashtas (agents) and several inhabitants of the said Subah, and that these bring forward false excuses as regards the payment of the same. He hopes that from the court of sovereignty the exalted order may be issued that they (*i. e.*, the officers) should help him in the recovery of the amounts due to him.

'The world-ruling order which is obeyed by the universe is now issued that, provided the truth of his complaint is proved, they should help and assist him in the recovery of whatever is necessary as due to the applicant from those persons according to the documents and accounts, and they should so act that the money of the applicant should not be withheld by any one contrary to his accounts. They should consider this as urgent.

'Written on the 16th of Jumad-ul-awwal of the first year of the august accession (30 January, 1659).'

The last of the Shantidas farmans.

We have now reached the last of the long series of the Shantidas Farmans. It was probably granted by Aurangzeb in the very last year of Shantidas's life, for it is dated March 12, 1660, and was evidently intended to mark the Emperor's appreciation of his services rendered during the War of the Succession. The contents are of unique interest inasmuch as not only is Shantidas confirmed in the possession of the village, hill and temple of Palitana, including the grass and the timber on the hill, but the great jeweller now receives at the end of his career a further grant of the hill and temples of Girnar under Junagadh and of Abu under Sirohi as a special favour. The language of the farman, however, makes it clear that they are all given to him in trust for the use and worship of the Shravak community. The document being one of those recently discovered, and not yet published, we give a full translation of the same. The language of the *Toghra* is to be noted for, instead of the usual full name and titles of the sovereign, we have an exhortation to the faithful to obey Allah and his Prophet—a departure from normal terminology quite in keeping with the character of this puritanical sovereign.

4. Aurangzeb's grant of Abu and Girnar to Shantidas, 12 March, 1660.

'In the name of Allah, the compassionate and the merciful. (*Toghra* in vermilion). 'O ye Faithful, obey God and obey the Prophet and those in authority from amongst you.

(Square lineal seal) 'Abul Muzaffar Muhi-ud-din Muhammad Aurangzeb Alamgir Badshah Ghazi.

'At this time the exalted Farman is issued that since Satidas Jawahari, son of Sahasbhai, of the Srawak community, has solicited and been hopeful for special favours, and has greatly helped the army during its march with provisions, and expects to be honoured with special rewards, therefore, the village (*deh*) of Palitana, which is under the jurisdiction of Ahmadabad, and the hill of Palitana famous as Satrunja, and the temple on it, all these we give to the said Satidas Jawahari of the Srawak community. Further that the grass which grows there may be used for grazing by the animals and cattle of the Srawak community; and the timber and fuel which is to be found on the hill of Satrunja should belong to the Srawak community so that they may utilise these for whatever purpose they like. Whoever guards the hill of Satrunja and the temple should be entitled to the income of Palitana and they should continue in prayer for the maintenance of the eternal government. It is necessary that the

administrators and officers and the jagirdars and the karoris of the present and future should absolutely not allow any deviation or alteration in this.

'Besides this, there is a mountain in Junagadh famous as Girnal (Girnar) and there is another hill at Abuji under the jurisdiction of Sirohi. We give these two hills also to Satidas Jawahari of the Srawak community as a special favour so that he may be entirely satisfied. It is necessary for the officers that they should not allow any one to interfere with these, and no one among the Rajas should obstruct him, and they should always help him as such action will bring royal pleasure.

'And they should not demand a new sanad every year and if anybody makes any claim about that village and the three hills which we have given to him he will be liable to the censure and curses of the people as well as of God. Another separate sanad has also been given to him.

'Written on the tenth of Rajab in the Hijri year 1070 (March 12, 1660).'

This then is the last of the farmans hitherto known as secured by Shantidas from the Mughal Emperors. The exact date of his death is a matter of some difficulty. Here the Jain literary works, which are so valuable in many respects, come to our help, and we learn from the poem known as the *Rajsagarsuri-Nirvānras* composed in Samvat 1722 (A.D. 1666) that the great Shantidas died in Samvat 1715[1] which ended on October 5, 1659 A.D. The Farman just described, however, is dated March 12, 1660. This discrepancy cannot be satisfactorily explained until some further information comes to light. It is, however, possible that the news of the great jeweller's death did not reach the Mughal court until after the date of the issue of this farman.

Death of Shantidas, 1659.

As the date of Shantidas's birth is unknown, we can only form a rough idea of his age at the time of his death, but if we suppose that he was at least twenty years of age at the time when he installed the image of Mahasnath on the sacred hill of Shatrunjaya in 1612-13, he must have been about seventy years old at the time of his death. Judging by the high esteem in which he was held at the courts of Jahangir and Shah Jahan, and the facility with which he could secure sanads from one Imperial ruler after another, we must conclude that

The foremost personality in Gujarat in his day.

1. Cf. સંવત સતરસિ વરસ પનરોત્તરિ, અહ્મારઇ પ્રાણ આધાર
સાહ શાંતીદાસ રે સુરલોકિં ગયો, તિહાં અહ્મા જાવું નિરધાર.
—Jain Aitihasic Gurjar Kavya-sanchaya. Ed. by Jinvijayaji, text, p. 58.

he was in many respects the foremost personality in Gujarat during the first half of the 17th century outside the ranks of the Mughal hierarchy. Already in 1640, the *Chintamani-prashasti* describes him as 'well known at the court, with the royal favour indicated by the gift of many swift horses and fiery elephants, and an ornament to the city of Ahmadabad.'[1]

1. The celebrated French jeweller and traveller M. Jean Baptiste Tavernier, who was in Ahmadabad ten or twelve times during his many voyages to the East, relates in some detail a most absurd story about 'the wife of a rich Banian merchant named Shantidas,' who was for long without a child, and who was *enceinte* as the result of eating some fish on the advice of an attendant. Some time after, the husband died, and she gave birth to a posthumous child whose right to inherit the father's effects was denied by the relatives as she had been without any issue for over 15 years. The matter was taken to the Governor and, on the advice of the doctors, the legitimacy of the child was established by the fact that, as expected by these experts, it smelled of fish when taken to the bath some days after the confinement! (Tavernier: *Travels in India.* Ed. by Ball, I, 75-6).

THREE FORGOTTEN PALLAVA KINGS

When studying Pallava History we generally examine Pallava inscriptions only. Thus the names of three Pallava Kings have escaped the notice of the scholars, for they are only mentioned in the inscriptions of the Kadambas of Banavāsi. These kings are called Naṇakkāsa, Śāntivarman, and Chaṇḍadaṇḍa. Their history in connection with the Kadamba Kings is as follows.

During the second half of the fifth century—in 475 according to Mr. Moraes—there occurred a split in the Kadamba family. King Śāntivarman seems to have died at about this time; his brothers, Kṛishṇavarman and Kumāravarman, declared themselves independent in Triparvata and Uchchangi respectively, instead of acknowledging Mṛigēśavarman, their nephew as lawful king of Banavāsi. Uchchangi seems to have been the capital of the western province.

The capital of the South was Triparvata. This city has changed its name twice at least. It was called Dōrasamudra under the Hoysaḷa kings. The Emperors of Vijayanagara changed this denomination into Halebiḍu, which is still the present name. It is situated in the Belur Taluqua of the Hasan District in the State of Mysore.[1]

Kṛishṇavarman I did not reign long at Triparvata, for he was already an old man when he ascended the throne, as he was the brother of the deceased King of Banavāsi.[2] Yet before his death his new kingdom suffered a tremendous set-back. An inscription found in the Devanagere Taluqua of the Mysore State informs us that the Pallava King Naṇakkāsa completely routed Kṛishṇavarman's army. Furthermore the epigraph adds that Śivanandavarman " whose country was thereby ruined, retired from the world after this battle, and betook himself to a forest wishing to live a life of penance, prayer and solitude."[3] The authors who have studied these inscriptions do not agree as regards the identification of this Śivanandavarman. Mr. Rice is of opinion that he is probably a younger son of Kṛishṇavarman.[4] But Mr. Moraes contradicts this view, for Śivanandavarman is said to be of the Atrēya gōtra, born in the Sōma-vaṁśa while the Kadambas were of the Mānavya gōtra and sons of Hāriti. According

1. Cf. Heras, *Triparvata*, *K. H. R.*, I, pp 13-18.
2. Mr. Moraes, *The Kadamba Kula*, p. 15, chart, gives him five years, from 475 to 480.
3. *E. C.*, XI, Dg. 161.
4. Rice, *Mysore and Coorg*, pp. 24, 25.

to him Śivanandavarman may probably be a brother of Kṛishṇavarman's wife who is said to be "the daughter of Kaikēya"[1], for Śivanandavarman himself was "born also in the family of the Kēkayas."[2] The opinion of Mr. Moraes seems to be the soundest one. A short phrase of the Devanagere inscription which has been overlooked hitherto seems to confirm this view. The inscription states that as a result of the battle with the Pallava army, Śivanandavarman's country was ruined. His country was therefore different from the Kadamba country, as he did not belong to the Kadamba family. He seems to have been an independent ruler who had succeeded his father Kēkaya. He may have been a brother of the Kadamba Queen. This proves that Naṇakkāsa fought against the combined forces of the Kadamba king Kṛishṇavarman I and the Kaikēya prince Śivanandavarman.

The result of this victory of Naṇakkāsa was two-fold; first of all the Kaikēya territory seems to have been annexed to the Pallava kingdom, for the inscription avers that it was ruined and that its ruler took up *sannyāsa*. As regards the Kadamba kingdom of Triparvata an annexation was not effected, but Kṛishṇavarman II undoubtedly had to acknowledge the suzereignty of the Pallavas, as the fact we are going to relate just now sufficiently proves.

Kṛishṇavarman I had two sons, Vishṇuvarman and Dēvavarman. The latter is only known through the Dēvagiri plates issued by him in the time of his father.[3] The former succeeded him, but apparently an obstruction occurred before his enthronement. Probably, as Mr. Moraes suggests, "Mṛigēśavarman or some other king of the elder branch of the Kadamba family tried to prevent Vishṇuvarman's succession to his father's throne."[4] On this occasion his overlord the Pallava king, "installed him on his throne,"[5] probably by marching an army on Triparvata and even defeating the king of Banavāsi (though this is not mentioned in any epigraph). Now this Pallava king who thus helps the branch of Triparvata is not called Naṇakkāsa, but Śāntivarman. What was his relationship with Naṇakkāsa? The epigraphical records do not give the slightest hint to solve this problem. Yet the continuation of dealings with the Kadamba family of Triparvata makes one realise that Śāntivarman must have been the successor of Naṇakkāsa, and in the ordinary course even his son.

The Kadamba King of Banavāsi, Mṛigēśavarman, could not stand such a humiliation and probably a few years later invaded the Pallava

1. *E. C.*, V, Bl. 121.
2. *E. C.*, XI, Dg. 161. Cf. Moraes, *The Kadamba Kula*, p. 41.
3. Fleet, *Sanskrit and Old Kanarese Inscriptions*, *I. A.*, VII, p. 34.
4. Moraes, *op. cit.*, p. 41.
5. *M. A. R.*, 1925, p. 28.

territory with such great success that as said in one of his copper-plate inscriptions, "he was a very fire of destruction to the Pallavas."[1] The Pallava king defeated on this occasion is not mentioned. Probably he was the same Śāntivarman, and even one may perhaps suspect that he was killed in this battle, for the Pallava king whom we find associated with the Kadamba King of Triparvata shortly afterwards is not Śāntivarman any more.

Before this event took place, two kings had succeeded to the throne of Banavāsi. At the time of Mṛigēśavarman's death, his son Ravivarman seems to have been very young. Accordingly Mṛigēśavarman's cousin, Mandhātrivarman, the son of Kumāravarman of Uchchangi, took possession of the throne of Banavāsi, which he did not fill up for very long. After his death, the young Ravivarman succeeded.

It was probably then that Vishṇuvarman, the Triparvata king, attacked the kingdom of Banavāsi, hoping perhaps, that the young king would not be able to defend his own throne and thus he would be able to take possession of the whole Kadamba kingdom. Vishṇuvarman was naturally helped in this enterprise by his ally the Pallava King. The latter is called Chaṇḍadaṇḍa and is styled "the Lord of Kāñchī". This war ended in a tremendous disaster for the allies. Ravivarman "slain Śrī Vishṇuvarman and other kings" and "uprooted Chaṇḍadaṇḍa, the lord of Kāñchī."[2]

As regards this king Chaṇḍadaṇḍa we find ourselves in the same difficulty as in the previous case. His relationship with Śāntivarman is not given. Yet he seems to be his successor and most likely even his son, as he continues the relations of the two previous kings with the Triparvata rulers. Thus we may draw the following pedigree with the greatest possibility of attaining the real state of relationship among these three kings.

Naṇakkāsa
|
Śāntivarman
|
Chaṇḍadaṇḍa.

Now, who were these three kings? In all the series of Pallava inscriptions one does not come across kings bearing such names. Mr. Moraes thinks that Naṇakkāsa might belong "to one of the many branches of the Pallavas, whose inscriptions have not come down to us".[3]

1. Fleet, *Sanskrit and Old Kanarese Inscriptions*, *I. A.*, VI, p. 25.
2. *Ibid.*, p. 30.
3. Moraes, *op. cit.*, p. 40.

It was common opinion among authors of Pallava History a few years ago, that there had been petty dynasties of Pallava kings all over Toṇḍamaṇḍala. Yet, after the publication of my *Pallava Genealogy* the existence of such dynasties does not seem very probable. In any case, Chaṇḍadaṇḍa is called " the lord of Kāñchī " in the inscription, and since the other two seem to be his ancestors and immediate predecessors, they also must have been ruling from Kāñchī. Moreover their power and influence extending to South Karṇāṭaka evidently shows that they were not petty chiefs, but rulers of a vast and resourceful kingdom.

It may be supposed that the three names given in the inscriptions of the Kadambas are only synonyms with the Kings referred to by other names in the Pallava epigraphs. It is well known that the Pallava kings had several titles and they used them indifferently in the inscriptions. Yet there is not a single synonym of the Pallava kings known to us through Pallava inscriptions similar to these names of the Kadamba inscriptions. On the other hand though Naṇakkāsa and Chaṇḍadaṇḍa sound like titles, Śāntivarman seems to be the real name of the king, as much as Buddhavarman or Mahēndravarman. Hence the best way to identify these kings and to trace their place in Pallava history, will be the comparative chronology of the Pallava and Kadamba dynasties.

Fortunately we have a point of contact, of uncontrovertible certainty, between these two Dynasties. The Aihoḷe inscription of Pulikēsi II narrates this king's attack against Kāñchī, and the extinction of the Kadamba Dynasty of Banavāsi as two actions of the same campaign. Hence the Kadamba King dethroned by Pulikēsi was contemporary with the Pallava King that fought with Pulikēsi round the walls of Kāñchīpura. This king by common accord of the scholars was Mahēndravarman I.[1] Therefore, we shall be able to draw the following table chronologically arranged, from the time of the first conquest of Kāñchī by Vijaya-Skandavarman = Kumāravishṇu, down to the fall of Banavāsi.[2]

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1. Cf. Heras, *Studies in Pallava History*, pp. 31-33.

2. For the Kadamba chronology I accept the dates of Moraes, *op. cit.*, p. 15, chart. The Pallava dates are from Heras, *op. cit.*, pp. 22-33, 62-65. I have followed the general rule of giving 25 years of rule to each king, excepting a few cases in which for special reasons more or few years have been granted. Thus Mahēndravarman I seems to have had a very long reign, as he left so many caves carved by him all over his vast kingdom. While on the other hand, Siṁhavarman II could not have had such a long reign for he succeeded to the throne after the death of his cousin Nandivarman I. Hence he has been given 18 years only.

Years	*Kadamba History*	*Pallava History*
325	... ...	First conquest of Kāñchī by Vijaya - Skandavarman = Kumāravishṇu in the time of his father, Skandaśishya.
331	... ...	Death of Skandaśishya. Vijaya - Skandavarman = Kumāravishṇu succeeds him.
334	Mayūraśarman goes to Kāñchī to learn Sānskṛit lore.	
345	Beginning of Mayūraśarman's reign in Kuntala.	
358	... ...	Death of Vijaya-Skandavarman = Kumāravishṇu. Buddhavarman succeeds him.
370	Death of Mayūraśarman. Kaṅgavarman succeeds him.	
388	... ...	Death of Buddhavarman. Vīravarman succeeds him.
395	Death of Kaṅgavarman. Baghīratha succeeds him.	
412	... ...	Death of Vīravarman. Skandavarman II succeeds him.
420	Death of Baghīratha. Raghu succeeds him.	
430	Death of Raghu. Kākusthavarman succeeds him.	
437	... ...	Death of Skandavarman II in Āndhradēśa, Siṁhavarman I succeeds him.
450	Death of Kākusthavarman. Śāntivarman succeeds him.	
467	... ...	Death of Siṁhavarman I in Āndhradēśa. Vishṇugōpa succeeds him.
475	Death of Śāntivarman of Banavāsi. Mṛigēśavarman succeeds him. Kṛishṇavarman I proclaims himself independent at Triparvata.	

Years	Kadamba History	Pallava History.
478	Probable date of Kṛishṇavarman's defeat by the Pallava Naṇakkāsa.	*Naṇakkāsa defeats Kṛishṇavarman I.*
480	Death of Kṛishṇavarman I of Triparvata. Difficulties put to his son before succession. *Interregnum.*	
485	Vishṇuvarman, Krishṇavarman I's son, is enthroned by Śāntivarman Pallava at Triparvata.	*Śāntivarman enthrones Vishṇuvarman at Triparvata.*
490	Death of Mṛigēśavarman of Banavāsi. Mandhātrivarman succeeds him.	
492	... ...	Death of Vishṇugōpa in Āndhradēśa. Skandavarman III succeeds him.
497	Death of Mandhātrivarman of Banavāsi. Ravivarman succeeds him.	
498	Ravivarman slays Vishṇuvarman of Triparvata on the battlefield and defeats Chaṇdadaṇda, the Lord of Kāñchī. Beginning of reign of Siṁhavarman of Triparvata.	*Chaṇḍadaṇḍa is defeated by Ravivarman of Banavāsi.*
517	... ...	Death of Skandavarman III in Āndhradēśa. Nandivarman I succeeds him.
537	Death of Ravivarman of Banavāsi. Harivarman succeeds him.	
540	Death of Siṁhavarman of Triparvata. Kṛisṇavarman II succeeds him.	
542	... ...	Death of Nandivarman I in Āndhradēśa. Siṁhavarman II succeeds him.

Years	*Kadamba History*	*Pallava History*
547	Krishṇavarman II of Triparvata succeeds to the whole Kadamba kingdom at the death of Harivarman of Banavāsi.	
550	... ...	Death of Siṁhavarman II in Andhradēśa. Siṁhavishṇu succeeds him.
555	... ...	Second conquest of Kāñchī by Siṁhavishṇu.
565	Death of Kṛishṇavarman II. Ajavarman succeeds him.	
575	... ...	Death of Siṁhavishṇu. Mahēndravarman I succeeds him.
606	Death of Ajavarman. Boghivarman succeeds him.	
610	End of Boghivarman's reign and of the Kadamba dynasty defeated by Pulikēśi II.	Battle between Mahēndravarman I and Pulikēśi II.

The result of this chronological comparison between the Kadamba kings and the Pallava kings is most amazing. For the three Pallava kings who interfered in Kadamba affairs happen, according to our calculation, to be contemporaries with the Pallava kings that ruled over Āndhradēśa during the so-called Chōḷa *interregnum*. Thus :—

Naṇakkāsa contemporary with Vishṇugōpa;
Śāntivarman „ „ Vishṇugōpa;
Chaṇḍadaṇḍa „ „ Skandavarman III.[1]

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1. Just when this paper was going to the press, an article by Pandit Lochan Prasad Pandeya of great interest reached my hands. The Pandit when comparing the inscriptions of the Pallavas, of the Vākāṭakas and of the early Kadambas paleographically, fully agrees with the above chronology. According to him the period occupied by the Kadamba Kings, Krishṇavarman I, Vishṇuvarman and Ravivarman—with whom the three forgotten Pallava kings had dealings—coincides with the period of the rule of Skandavarman II, Siṁhavarman I, Vishṇugōpa, Skandavarman III, Nandivarman I and Siṁhavarman II, that were the Pallava Kings who ruled from Āndhradēśa. Even the dates given by the Pandit roughly agree with the above dates. The period of *interregnum* according to him ends in 550, that is the date of Siṁhavarman II's death and beginning of the reign of Siṁhavishṇu, according to the above chronology. The beginning of this period of *interregnum* is the only point in which the Pandit differs, for while the Pandit assigns the period 450-475 to the reign of Skandavarman II, the above chronology gives the period 412-437. Cf. Pandeya, ***The Box-headed Characters in use in Mahakosala***, शारदाश्रम-वार्षिक, 1933, p. 25.

Is this a sufficient reason to identify these three kings with those rulers of Āndhradēśa ? Such identification would not be warranted :—

1st. For the fact that they lived at the same time does not guarantee that the two persons are one and the same, especially having such different names.

2nd. For two of these kings, Naṇakkāsa and Śāntivarman appear to be contemporary with Vishṇugōpa. If both are identified with the latter, they would also be one and the same person, their names being so different.

3rd. One of these kings, Chaṇḍadaṇḍa is called " the lord of Kāñchī ", and the other two, who seem to be his predecessors, would also be ruling from that city ; while neither Vishṇugōpa nor Skandavarman III ruled from Kāñchī, but in Āndhradēśa only. Who, therefore, were these three kings ?

The span of time during which the Pallava kings issued grants from Āndhradēśa till the conquest of the Chōḷa country by Siṁhavishṇu has always been a puzzle to the Pallava historians. The Pallava rulers have left Kāñchīpura, they issue their grants from and apparently in Āndhradēśa. What was the reason of the abandonment of their capital and of this retreat to the northern part of their kingdom ?

In order to solve this problem, some authors, among them the present writer,[1] have recurred to a Chōḷa *interregnum*, which is not warranted at all by any contemporary evidence. They supposed that the Chōḷas, from whom the city had been conquered by Vijaya-Skandavarman = Kumāravishṇu[2], had wrested it again from the hands of the Pallavas and had kept it till finally Siṁhavishṇu conquered the whole country of the Chōḷas[3] and Kāñchī with it.

Mr. Gopalan, besides emphasizing the fact that no inscription speaks of this Chōḷa occupation, raises serious objections against it.[4]

The appearance of these three Pallava kings precisely at this moment of Pallava history is the real explanation of this difficulty. They are three kings, who ruled from Kāñchī—one of them beyond doubt, the other two most likely—when the kings of the main line had abandoned this city and were ruling from Āndhradēśa. They belonged therefore, to a side branch of the family who had dispossessed the main one of their capital Kāñchīpura and were ruling from this city most successfully—at least in the beginning—as their intervention in the Kadamba kingdom discloses.

1. Cf. Heras, *Studies in Pallava History*, p. 18.
2. Cf. *Ibid.*, pp. 9-16.
3. *S. I. I.*, II, pp. 550 and 356.
4. Gopalan, *History of the Pallavas of Kānchi*, pp. 64–65.

Was the first of these three kings, Naṇakkāsa, the one that dispossessed Skandavarman II, (the first king we find ruling in Āndhradēśa), of his capital? We have no evidence to reply to this question with full certainty, but if our calculations are correct, there is no need of placing any other king before him. Skandavarman II died in exile in about 437. He seems to have suffered the humiliation of losing Kāñchī in his old age, for he issued the Omgōḍu plates A from Tamprāpa,[1] while his second son, Vishṇugōpa, was old enough to issue the Uruvapalli plates from Palakkada, almost at the same time.[2] Therefore we may place the conquest of Kāñchī by Naṇakkāsa round the year 435. Now the same Naṇakkāsa appears defeating Kṛishṇavarman I of Triparvata in 478, *i. e.*, 43 years later; after which he died soon, for seven years after, in 485, we hear of his successor, Śāntivarman. Therefore, supposing that he was 30 when he rose against Skandavarman II, he was only 73 when he defeated the king of Triparvata. This supposes a reign of 43 or 45 years. We hear of such long reigns occasionally, even in Pallava history. Nandivarman Pallavamalla ruled for 65 years.[3]

What was Naṇakkāsa's relationship with Skandavarman II? His long reign after the conquest of Kāñchī does not allow us to suggest that he was Skandavarman's brother. For then he would have been of a ripe age at the time of the conquest, and could not have lived 43 years after that event. His young age at the time of the conquest of Kāñchī forces us to suppose that he belonged to a later generation. We cannot imagine that he was the son of Skandavarman, for such a conduct of a son towards his father cannot be presupposed until it is well substantiated. He may have been a nephew of Skandavarman, a son of one of his brothers.

What was the reason and the occasion of this rising? The ultimate reason of all risings is ambition, but on this occasion perhaps the cause of this rising was a nobler one. It was Skandavarman II whose son, Vishṇugōpa, was defeated by Samudra Gupta[4]. Since Skandavarman was dispossessed of Kāñchī towards the end of his reign, the defeat had to occur during the life time of Skandavarman, for the inscription calls Vishṇugopa "Vishṇugōpa of Kāñchī". Now two consequences may be derived from this fact:

1st. That Skandavarman was not a war-like monarch, since at the approach of the enemy, he sent his son only to fight him, he himself remaining under his palace shelter.

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1. *E. I.*, XV, pp. 249-252.
2. *I. A.*, V, p. 50.
3. 666 of 1922.
4. Allahabad Pillar Inscription of Samudra Gupta, Fleet, *Gupta Inscriptions*, p. 13.

2. That Vishṇugōpa's defeat raised much feeling among the subjects against him and his father.

Naṇakkāsa may have been the leader of this patriotic movement, as he finally succeeded in defeating those two persons, unworthy to occupy the throne of Kāñchī.

This victory proves that Naṇakkāsa was a worthy scion of the Pallava family and was undoubtedly the cause of enthusiastic support received from the whole nation. It was not strange, therefore, that he could lead his victorious army as far as Triparvata and could establish his influence there so firmly as to last three generations.

From the time of the intervention of the third of these kings, Chaṇḍadaṇḍa, in Kadamba affairs till the return of the main line of the Pallavas to their traditional capital,—an event that seems to have taken place in the time of Siṁhavishṇu—there is a gap of 57 years that would admit another king. Is there any likelihood of his existence? We do not dare to give a definite reply to this question. Yet, we may draw attention to that fact that between the victory of Naṇakkāsa over Kṛishṇavarman I of Triparvata and the defeat of Chaṇḍadaṇḍa by Ravivarman, only 20 years elapsed. Hence the reign of Śāntivarman that must be placed between these two dates must not in ordinary circumstances have exceeded 15 years. This proves that this king died relatively young, and that his son, Chaṇḍadaṇḍa, ascended the throne at a very early age. Hence he could very easily reign 57 years.

We have no information at all about the end of Chaṇḍadaṇḍa's rule. But the fact that the reconquest of Kāñchī is not mentioned at all in Pallava inscriptions, not even referring to Siṁhavishṇu, whose wars against several kings are twice mentioned,[1] seems to suggest that Kāñchī was actually not recovered by conquest, but by a peaceful possession of it. This implies that Chaṇḍadaṇḍa might have died childless, and that consequently the main line of the family whose representative was then Siṁhavishṇu, was again recalled to guide the destinies of the kingdom. This extraordinary turn of fortune was undoubtedly the cause of victorious campaigns. When he found himself again on the throne of his ancestors, at the head of such a vast kingdom, he felt courageous enough to enlarge his territories with that success which is well known to all.

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1. Cf. Vēlūrpālaiyam plates of Nandivarman III, *S. S. I.*, II, p. 510; Kaśākudi plates of Nandivarman Pallavamalla, *Ibid.*, p. 356. In the supposition that the Chōḷas were in the possession of Kāñchī, I considered the conquest of Kāñchī included in the general phrase of the Vēlūrpalaiyaṁ plates referring to Siṁhavishṇu: "He quickly seized the country of the Chōḷas" Cf. Heras, *op. cit.*, pp. 19-21. Now since we know that the Chōḷa *interregnum* did not take place, it is evident that the reconquest of Kāñchī by the main line of the Pallavas is not referred to at all in the epigraphs.

Accordingly the order of events with tentative dates may be given as follows:—

412. Skandavarman II succeeds to the throne of Kāñchī.

435. Naṇakkāsa succeeds in defeating Skandavarman II and taking possession of Kāñchī.

437. Death of Skandavarman II in Āndhradēśa. Siṁhavarman I succeeds him.

467. Death of Siṁhavarman in Āndhradēśa. Vishṇugōpa succeeds him.

478. Naṇakkāsa defeats Kṛishṇavarman I of Triparvata.

480. Death of Naṇakkāsa of Kāñchī. Śāntivarman succeeds him.

485. Śāntivarman of Kāñchī enthrones Vishṇuvarman of Triparvata.

492. Death of Vishṇugōpa in Āndhradēśa. Skandavarman III succeeds him.

495. Death of Śāntivarman of Kāñchī. Chaṇḍadaṇḍa succeeds him.

497. Chaṇḍadaṇḍa of Kāñchī is defeated by Ravivarman of Banavāsi.

517. Death of Skandavarman III in Āndhradēśa. Nandivarman I succeeds him.

542. Death of Nandivarman I in Āndhradēśa. Siṁhavarman II succeeds him.

550. Death of Siṁhavarman II in Āndhradēśa. Siṁhavishṇu succeeds him.

555. Chaṇḍadaṇḍa of Kāñchī dies childless. Siṁhavishṇu succeeds to the whole kingdom.

H. HERAS, S. J.

DEVELOPMENT OF CONSTITUTIONAL IDEAS IN THE HISTORY OF THE MARATHAS.*

(a) *From 1750 to 1761.*

The Minister supersedes the Monarch.

Shahu, the last of the de facto sovereigns of the Marathas died on 15th December 1749. With him virtually ended the rule of the Bhonsale monarchy. After an initial struggle of some five years, Shahu could settle down in the peaceful possession of only a few square miles. The Mughal grant of Swarajya was yet to be effective by the strength of his sword. Fortunate in his assistants, especially in his Peshwa, Balaji Vishwanath and the Commander-in-Chief, Dhanaji Jadhavrao, he soon regained his rightful possessions. His second Peshwa, Bajirao I, was impatient for expansion in the North. His third Peshwa, Nanasaheb, was equally efficient, and Shahu after a long and happy reign of about 40 years, died the master of an extensive territory and the Suzereign of scores of sardars, capable of mobilising lakhs of soldiers on the battle-field.

Shahu enjoyed real power in his life-time. He dictated policies, directed campaigns, threatened[1] and effected dismissals[2] of Peshwas, and tried to control the contending factions among his powerful servants, including the Astapradhans. And though, Shahu was somewhat partial to the Peshwa against the established convention, he did nothing intentionally that would injure the constitutional position of the rest of his council of eight.

But the circumstances conspired against the absolute preservation of the conventions of old. The hereditary principle rendered the choice of capable persons generally impossible. The extraordinary exception in the case of the Peshwa's family transferred much of the important state-business and the monarch's confidence to him by the process of natural selection. Consequently the serviceable convention of the superiority of the Peshwa over the others was being developed in the very lifetime of Shahu. The power and partiality of the king reinforced the developing strength of the Peshwa. Shahu thus may be

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* This article is a chapter from a thesis on the Social Life and Manners in Maharashtra from 1750-1800, which was submitted in 1928 by Mr. D. V. Kale for the degree of Master of Arts.

1. Rajwade, VI, p. 16.
2. Sardesai, II, p. 109.

compared to the Georges in England, with this difference that it was the non-intervention of the latter and not active support as in the case of Shahu, that raised the importance of the Prime Minister in England.

The crowning point was soon reached. Shahu a little time before his death and under peculiar circumstances[1] had to hand over the supreme power of the kingdom to the Peshwa, Balaji Bajirao.[2] Two notes in Shahu's own handwriting contain this transfer of power. It is remarkable that the only document or documents of any constitutional importance in the Maratha administration should be written under such circumstances and should be so much an object of controversy. That they created a new power in the land (the only power, owing its authority to a written document) cannot be denied. The notes raised the first servant of the state into its autocratic master.

The fact of the rise of a power based upon a written document need not deceive us of the real nature of the situation. The document was the expressed will of a despot who could presume to bind the whole of the posterity by his order. To speak in the language of the constitutional practice of the day, it was the duty of the Peshwa to obey the order of his sovereign.

Whatever may be the nature of the effected change and its sanction, it is certain that the change was fraught with immense consequences. Before 1750, the Peshwa was merely an executive officer of the King. In one important matter, at least, the liberty of action of the Peshwa was considerably limited by Shahu. Shahu's regard for the power at Dehli imposed a limitation on Bajirao I's zeal for expansion.[3] He created obstacles in Bajirao's way when he proposed to invade Mogal territory.[4] Shahu seemed to relent even towards the Nizam probably because he was the Subhedar of the Dehli Emperor. To this extent Shahu, as the head of the Maratha kingdom, seems to have swerved from the original ideal[5] of independence. The Peshwa had to own allegiance to the king and was guided in every matter by Shahu's susceptibilities, whatever his own ideas might be as to the ideal of ' Maharashtra Dharma '.

Shahu's death and the two notes in his hand-writing removed any check on the Peshwa's action. And the directive and the executive power, the statesman and the Commander-in-Chief, the diplomatic and the military authority again combined, after they had been separated for the last 36 years. Whether as a result of the consciousness of the new power, or being forced by circumstances, we see the Peshwa,

1. Sardesai, II, p. 119 *infra*.
2. *Itihas Sangr. Sphut*, IV, p. 15.
3. Bharatavarsha Shahu Bakhar, pp. 81-82.
4. Sardesai, I, p. 163.
5. Sardesai, *Main Currents*, p. 99.

in his own name and through the instrumentality of his sardars, undertaking the high responsibility of administering the Emperor's possessions and protecting them against a foreigner like Abdali.[1]

But in all his ambitious schemes the Peshwa had to depend upon his own unaided resources. The rest of the Ashtapradhans were by no means interested in his schemes of expansion. The power and the prestige of Shahu, which effectively curbed the forces of opposition, had now disappeared. And a great part of Balaji Bajirao's time and energy was wasted in making himself secure in his position by being feared if not respected by his former colleagues. The blunder of crushing the Angres in 1756 and the neglect to support the Bhonsale's claim in Bengal were but the unfortunate offshoots of the policy dictated by that supreme need of the situation.

The unification of the supreme command was not, however, without its benevolent results. The vigorous policy of the Peshwa on all sides, soon convinced the statesmen in the adjoining kingdoms that the Marathas aspired to the mastery of India. And however seriously the affairs in the north might have been bungled, on account of the unhappy choice of Raghunathrao to initiate policies in the north or the culpable neglect of composing differences between the Shinde and the Holkar, there was no doubt in the minds of responsible persons that Panipat was undertaken by the Peshwa to strike once for all, for the mastery of the Empire.

To a certain extent the period of eleven years is a unity characterised by the supreme fact of the unfettered activity of the Peshwa. His efficient administration subdued all opposition to his power from within. A favourable result at Panipat would have still raised his prestige, both in the Maratha Mandala and the whole of India. The forces of opposition which were only suppressed for some time would have been completely destroyed and a fruitful peace would have followed. But Panipat spelt ruin to all developments which would have been constitutionally so very significant.

Innumerable things required improvement at the hands of a powerful central authority among the Marathas. Shahu's injunctions against expansion towards Delhi was not the only impediment to the growth of the Maratha power. His notes had imposed still more strange restrictions on the Peshwa. He was expected to continue all the thousand and one watans, which the exigencies of the precarious times of Rajaram and Shahu himself had rendered necessary.

Any power which wanted a tolerable kind of political expansion and development could not for a moment afford to harbour such seed-beds of inaction and stagnation. The powerful central authority ought

1. Rajwade, I, p. 1.

to have freely applied the scissors to this kind of wasteful claims upon the state treasury and a useless check on the manpower, and free development of the country. But the set-back at Panipat arrested constitutional development of any kind. The whole thing remained a stalemate at the stage it was left by the confused orders of a bewildered benevolent despot. Whatever may be the significance of the battle of Panipat from the point of view of the Maratha Empire as a whole, whether it be termed a horrid disaster or only the scene of suppressed ambition or taken to be an event of no serious importance, it is certain that it reduced the chances of a better administrative system being developed under the Maratha state.

(b) *From 1761 to 1773.*

Rapid Growth of Individualism.

Constitutionally the second period comes to an abrupt close at the death of Madhavrao I, but may be extended to the deplorable murder of the boy-Peshwa, Narayan Ballal, in 1773, for no other reason than that the latter's short reign provided no scope for any development which can be independently noted.

Balaji Bajirao, for reasons which can be easily imagined, roused opposition to his power and personality, on all sides. To the very large number of his opponents, therefore, the result of Panipat was significant. They took it to imply as if he stood his trial at Panipat and failed. In the more tangible world of facts, the Peshwa lost his army, wealth and prestige Panipat. His successor was a mere boy. And this was considered to be a very fit opportunity for both the internal and external forces of opposition to raise their heads. Some idea of the heavy work that confronted the young Peshwa, can be formed from the list of wars and their frequency, during the short reign of eleven years, of Madhavrao Ballal. The record of Maratha achievements which is otherwise very bright in other respects, was marred by two civil wars in 1762 and 1768, both between members of the same family, between Raghunathrao the uncle and Madhavrao I. The old divisions which had been somewhat suppressed by Nanasaheb Peshwa were again raked up and received a new lease of life. The battle of Rakshasbhuvan might be considered to be a civil war in all but name. It was the strength of Maratha sardars like the Pratinidhi and Gopalrao Patwardhan that had encouraged the Nizam to attack the Peshwa. Persons were so exasperated against each other and had been blind to the interests of the Maratha state as an entity. They had possibly no idea of a unity of any kind. Such a time was in no way helpful to developing healthy constitutional usages. And the inclinations of the Maratha sardars, which were originally towards individualism were shortsightedly encouraged by the saranjam system and developed by the policy and notes of Shahu.

They were further enhanced by the removal of a kingly power, which legitimately controlled them before and which they now readily considered to be extinct. The action of the Peshwa Balaji Bajirao, himself gave countenance to the same view. He was forced, in the face of constant opposition, to guide his policy more as an independent person rather than as the head of a constituted empire. The mentality of the people was never in favour of respecting constitutional or other fictions and they recognised only actualities. And these were obviously against any unity of control.

It must be said, however, that it was the forceful personality and the military forces at the command of the Peshwa that maintained the unity of the Empire and the prestige of the Peshwa. Though the house of the Peshwa was divided against itself there was strength enough in its various constituents, which could be effective against different enemies, if singly confronted. Fortunately for the Peshwas their enemies did not seek to combine among themselves. The striking success in the north, by which the Marathas became the protectors of the Emperor Shah Allam of Dehli and reinstated him in his throne (25-12-1771), was partly due to the weakness that reigned there and the unwillingness of the English to undertake any risk just at that moment.[1]

But the forces that opposed peaceful development were powerful and varied. There was no respite allowed to the Peshwa who was harassed throughout his life. Perhaps it might have been too early, to attempt any re-establishment or renovations, immediately after Panipat. Again Madhavrao I was granted a short life. He died in 1772 and had no time to do anything else than re-introduce some kind of honesty and accuracy in accounts, with a view to increase the efficiency of the administration.

He was succeeded by his younger brother. It is a pity that he did not enjoy his office for more than a few months. No constitutional development of any kind was possible under him and he died at the cruel hands of the Gardies employed by the nefarious agents of Raghunathrao. He died a victim to the family dissensions which his elder brother could control only by waging two civil wars. The atrocious crime of the Gardies was typical of the loss of respect, in the minds of the servants, for the representative head of the political power in the land.

(c) *From 1773 to 1796.*

Breakdown of the Bhat Hegemony : The Oligarchy of Service.

Though his uneventful life closed so abruptly, Narayanrao's death was more fruitful in the constitutional development of the

1. Kaifiyat Yadi etc., p. 159.

Maratha state, than even the very able reign of his more capable brother. The murder of a ruling officer by the hand of the assassin, in the interests of another claimant for the office, was extraordinary in the bloodless career of the Bhat family and revolting to the feelings of the ordinary man. The remonstrating letter of the Brahmin in Poona and the open defiance of Ramshastri Prabhune were only particular instances of the universal resentment that was roused against Raghunathrao.

The height of the crime made Raghoba's dearest friends like Sakharam Bapu desert him and the perpetrator of the deed could not be willingly received as a ruler, even in a land, where power was considered to be conferred by the grace of God. Cold politics transferred power to the perpetrator of the murder. But warm sentiment retreated its steps and organised opposition. What is democracy but an organisation where popular sentiment gives a tone to the prescribed course of constitutional politics ? If this be the expression of the inner meaning of democracy, we may consider it to have had its short day of currency even in Maharashtra.

But there were important limitations and a considerable difference in form. The power of the 'Barbhais' was not constituted in the name of the people, but only to protect the interests of the infant in the womb of the widow of the murdered Peshwa. The proper line of succession was respected and the despotic power of the reigning authority was never questioned. The justification for their bonding themselves together was not that they wanted to oppose constituted despotism, but that they wanted to see that the proper hereditary rights of the legitimate heir were not violated by the usurper. It was on the claims of moral justice that they laid emphasis, not on the absolute rights of their fellowmen as subjects.

But even this much was an unparalleled advance in the political ideas of the people. The Barbhais may be called a convention cabinet, a council of regency and a council constituted on the independent initiative of the councillors themselves. Some of the highest officers of the state felt themselves called upon to concern themselves in state affairs. This shows the great change effected in the originally passive, indifferent or extremely selfish and self-seeking mentality of the people. This change was no doubt due to the people's familiarity with the political problems of the last sixty years.

The Barbhais conducted themselves very admirably throughout the early operations of their regime. Statesmanship and military abilities though distributed among different individuals, now combined in what they considered to be the interests of the kingdom. Insignia of Peshwaship were soon secured for the infant Peshwa and the dowager Bai was given all possible importance in the conduct of the business

of the state. The Karbharis issued the orders in the name of the infant or the dowager and the soldiers showed the good sense to obey them and carried a leaderless war with the usurper to a successful end.

It was the good sense of the Karbharis that prevailed. Under any Mahomedan state, there would have been no end to the intrigues and assassinations and conspiracies that might have been started and carried to any length. The Karbharis might have usurped the sceptre themselves or the military sardars might have won authority by the strength of their arms. But any absence of extravagant greed or rapaciousness speaks volumes of the personal excellence and the superior morals of the Barbhais and the Marathas in general, compared with any other Indian rulers of the day. But this unusual experiment was destined to fail, inasmuch as it did not retain its form of 'administration by discussion' for very long. And soon the whole thing resolved itself into the domination of individuals. The two Karbharis—Sakharam Bapu and Nana Fadnis, stepped into the shoes of the Peshwa and wielded the power and authority of that figurehead.

The Peshwa, who was but an infant, was altogether out of the question, though the tradition of his chiefship was maintained in form. It is indeed creditable to the good sense and loyalty of the people that the name and prestige of the Maratha kingdom was maintained intact, even when the titular head was a mere child. But the credit shall have to be given to the ability of the Karbharis, who worked with a selfless zeal. Gradually the two Karbharis became prominent and conducted the business as long as and as far as two such able persons could pull on together.

The joint rule of Sakharam Bapu and Nana Fadnis and Moroba Dada (as the third of them for some days), was in itself an unprecedented thing. It ended with the imprisonment of Sakharam Bapu on a charge of treachery in the first war with the English. And later Nana Fadnis alone wielded the power of the Peshwa for about fifteen years.

It is remarkable how during this period of the rule of the Karbharis, they co-operated under compulsion and not by willing agreement. It was the mutual fear of the rivals' machinations that kept them together. Though the council of regency owed its origin to the genius of the Marathas, the details of administration including the methods of dealing with undesirable rivals were copied from the Mahomedans. There was no safety valve provided against disagreement, such as the quiet retirement of the one or the other. And imprisonment of the opponent or involving him in a treacherous business or detecting anything that would justify his removal was the only course feasible under the circumstances. Nobody of the Karbharis would willingly retire from the enforced co-operation. Nana Fadnis would not care to entrust the

business to Sakharam Bapu alone, nor would Bapu abstain from independent dealings without Nana's knowledge. Every one cherished the ambition of securing undivided control of the whole affair himself.

Nana Fadnis represented only the statesmanship of the Maratha Empire. He had to depend for military aid upon the sardars, who were the servants of the Peshwa. They habitually obeyed the orders of the Peshwa, given through Nana Fadnis and were content to serve the Empire according to their own whims. From 1774, therefore, the whole of the Maratha state was run by the able servants of the state, *i. e.*, by an oligarchy of service if we may call it so. The generality of the people might not have been able to conceive the essence of such things. The Sardars and the politically minded people, however, could not but be conscious of this immense change. The most powerful, ambitious and shrewd of them, Mahadji Shinde, who indeed rendered yeoman's service to the cause of the Maratha empire by re-establishing the Maratha power in the north in all its former glory and more, began to seek scope for his restless energy and ambition in the south as well. For a few years the Maratha Empire progressed apace from co-ordination of the military prowess of Mahadji and the statesman's genius of Nana Fadnis. But this combination proved but short-lived. It could not go on for a long time and that for the same reasons as dissolved the joint-Karbhariship. They co-operated only from a distance and under stress of circumstances, and fell out with each other when they came at close quarters.

For the present it will suffice to note the general features of the development traced so far. We have seen that the government of the country underwent no change, so far as its form was concerned. The governmental organisation of the Marathas as everyone knows, was headed by a hereditary crowned king. He was assisted by a council of eight or Ashtapradhans, which was constituted of the heads of different departments. Everyone of these was responsible to the king and to nobody else. The king was an absolute monarch, and ruled as he pleased, though he might sometimes take the advice of his ministers. The ministers were helped by a secretariat of innumerable clerks and officers like the Fadnis, etc.

This was the very stucture which was maintained down to the last days. And the king, the ministers and the servants and the sardars were filling their usual rôles when the kingdom last changed its master. The survivals of the old kingdom, the several states in the Bombay Presidency are examples of the continuance of the same structure to the very last days.

The king, even after the notes of Shahu, continued to stay in Satara, enjoyed special honours as before, was approached for the insignia of office, and was addressed with all due forms; but he had ceased to

play any important rôle in Maratha politics, till the Englishmen's interest finally reinstated him (1818). Thus from 1750 though Satara continued to be the residence of the Chhatrapati all political policy originated from Poona which was rising into importance.

The Peshwa enjoyed supreme authority from 1750 to 1773, when circumstances conspired practically to nullify the office as the then occupant was a mere child. During this period the forms were maintained but the business was conducted in the name of the Peshwa alone. This change was facilitated by the absence of a capable occupant of the throne. The sole authority devolved upon the Peshwa. No one of his equals in the council, not even the 'Pratinidhi' who was formally his superior, inspired the dying monarch with confidence in his ability. The notes preserve the form of a transfer by order of the king. They serve only to hide the details of the real process of the transfer of power from Shahu to the Peshwa, which was going on slowly. It is always natural that it should so happen. And the last transfer of power from the Peshwa to the Karbharis and the Fadnis, was only the continuation of the same process, which scientifically is embodied in the phrase 'survival of the fittest.'

The essence of power gradually passed from the King to the Peshwa and from him to the Fadnis. The Peshwa in theory exercised his power in the name of the king; and the Fadnis exercised it in the name of the Peshwa.

Why the name of the Peshwa is so well known and more held in respect than that of the Chhatrapati, is easy to explain. The activities of the Chhatrapatis were all exhausted in founding the kingdom. Just at the time when the Maratha kingdom was entering on a career of expansion, the Chhatrapati's line became extinct and no able person appeared in the line. It was with the Peshwa that the powers in India had to deal, in the heyday of the Maratha Empire.

People respected personalities, and the actual actor, and not the power behind him and whom he represented.

In the political *i.e.*, administrative organisation we see that there was no structural change. No new officer was appointed. No new forms were introduced. It were the same old forms that were retained and the change was only functional.

(d) *The development as a military State*

The people's share in the politics of the day.

To the majority of the common people, the arrival of Shahu (in 1707) who claimed to be the son of Sambhaji, possibly meant nothing. But to some of them at least the event might have been as delightful as the restoration in England. They were certainly tired of the continuous warfare that lasted for over 25 years. To the intelli-

gent people the fact that Shahu was to be sent down by the willing consent of Ajimshaha, might have suggested the prospect of peace and cessation of hostility with the implacable enemy of the Marathas. To some the arrival of a newer if legitimate[1] claimant might have suggested the possibility of a horrible civil war. Some might, therefore, seek to strengthen the existing power against the impending warfare. Others would strive to support the new power with a hope to make a profit at its hands. Above all others the sense of respect for the legitimacy of the scion of the elder branch would win in the end. And the proportion in which the one or the other of the sentiments predominated, the man would be found either in Shahu's or Tarabai's camp. We have no evidence to determine what considerations swayed the judgment of the people. We are sure that the common agriculturist must not have mattered. But that the several vatandars and Desais and Desh Kulkarnis mattered and were approached severally by the different claimants has been established beyond doubt. A letter[2] written by Shiwaji of Kolhapur about four months after the release of Shahu, to the Desai and Desh Kulkarni of Saitawade, is typical of the kind of appeal made to the important vatanholders in the land. It contained arguments in favour of Rajaram's and Shiwaji II's claims, precedents against Shahu, remonstrances against the entertainment of negotiations from Shahu and threats in case they were respected. It suggests that both the parties approached people with their respective negotiations. It sounds like persistent canvassing for support. If every Desai might be so written by both the parties we may postulate the presence of an informed public opinion on the question.

Towards expansion through peace.

We may suppose that Shahu's reign was rather quiet, cautious and uninspiring to the people, considering his peaceful tendencies and his readiness for compromise. On the whole, the period of restoration might have also been the period of settlement,[3] and general renovation in the department of agriculture[4] and such other peaceful pursuits which were so grievously disarranged in the recent wars. Under Shahu the Marathas fast recovered and were soon ready to undertake the ambitious schemes of Bajirao I and Balaji Bajirao. Shahu's cautious policy did not involve his subjects in any distant and destructive wars and to that extent the period before 1750 may be considered a period of preparation for the wide and ambitious schemes that were undertaken afterwards. The spirit of militarism, inherited from the wars with

1. Rajwade, XV, Rajaram's letter.
2. *Vividha Jnan Vistar*, Feb. 1924.
3. P. D. I., p. 222.
4. *Ibid.*, p. 130.

Aurangzeb was inspiring youthful minds to sham fights[1] and that was a clear sign that the young men of the coming generation were equipped with war mentality. It is very hard to distinguish in such matters between period and period and the year for demarcation can be only arbitrarily chosen. The year 1750 is by no means a specially significant year, from the point of view of the people, the vatandars and the sardars, though it must have meant so much to the Peshwa himself. The former i. e., the vatandars and sardars etc., remained to obey orders as previously and were allowed an unhampered possession of their hereditary vatans. The policy at the centre might have differed but they never sought to influence it at any time in history. They, no doubt, supplied the manpower to execute the plans emanating from Poona or Satara. They were thus bound to be infused with the enthusiasm that reigned either at Poona or Satara. And if we want to read the spirit of the times we must look to the political centre of the Empire. For "the king is the maker of the times."[2]

The Military State.

Without entering here into the discussion as to the real meaning of several catchwords used by the politicians of the day we can certainly say that all of them stood for the expansion of the political limits of the Maratha Empire. Whether it was the extremely comprehensive and baffling ideal of the 'Maharashtra Dharma' that was asserted or the more understandable 'Hindupad-padshahi' was the goal, both of them seem to have drawn the Marathas out of their own territories and drawn them to outside fields. And though statesmanship secured by negotiations what the ideal dictated, it could scarcely be enforced without the sanction of the sword. Thus whether Shahu owed his kingdom to the gracious firman of the Dehli Emperor or whether Malva was obtained by means of a sanad from the same respectable source, or whether the Maratha sardars undertook their campaigns about Dehli in the interests of the Emperor or whether Bhausaheb led his hordes to achieve the Hindu-pad-padshahi, all claims had to be made good by war. That was the order of the day. A long list of the campaigns, undertaken by the protagonists of the Maratha power may easily be cited in support of this contention.

War attracted the Marathas on all sides. In the south in the Karnatak, to the east towards the Nizam, to the north to strike at Dehli. And though Shahu's policy rather curbed the impatient programmes of Bajirao, the latter usually could find some business for his armies. Nana Saheb followed suit and we can assert, with ample justification, that within whatever limits it was possible to act, the

1. *Ibid.*, p. 183.
2. Ajnapatra, p. 16.

Maratha standard was held aloft both within and outside the territory of Swaraj. The naubat (Tabard) of the Maratha army sounded nearer home, southwards in Karnatak and in the north about Dehli. Immediately before the death of Shahu the Marathas were a respectable military power even in the north.

Aspiring for the Imperial Power.

Eleven years more, and the Marathas were looked upon as the next imperial power in India. The Maratha volunteers overran almost the whole of India. Over a lakh fought and died at Panipat and yet 25,000[1] could be spared for the protection of the south. It may be said that the activities of the Marathas before 1761 including of course those between 1750-1761 were such as to encourage a military outlook. That was the only field where an outlet could be possible to the majority of the able-bodied people. Foresighted statesmen like Bhausaheb were anxious to adopt the efficient system of drilled platoons for similar reasons. Sadashivrao Bhau was well impressed by the army of Bussy and employed Gardies in his service.[2] The most important feature of the Maratha army at Panipat was the artillery of Ibrahim Gardi, though the Maratha volunteers were conspicuous by their number and importance. The gardis or any other force as far as Panipat, was only employed as an auxiliary force. The military spirit of the common Maratha was still going strong.

Marathas fight shy of the North.

But the Marathas seem to have suffered from exhaustion after Panipat. At least they seem to have entertained some vague terror for campaigns in the North. The old Sardars, who came from the South accustomed to lead their own compatriots, no doubt depended upon the Marathas themselves, even in the North. But a feeling against the undisciplined hordes was growing apace in the minds of Sardars like Mahadji Sindia, who might be said to be quite post-Panipat in his career and outlook. Both these views are reflected in the correspondence of the day, indicating tendencies of a more or less permanent nature.

A letter in 1757[3] from Antaji Mankeshwar records that eight thousand of the twelve thousand army that he commanded, belonged to the Desh, *i. e.*, were native Marathas. The four thousand recruited in the north was merely for show. The genuine Maratha army was still considered a reliable source of strength by conservative politicians till 1780. We find Nana Fadnis enjoining against the demobilization of

1. Rajwade, I, p. 168.
2. Sardesai, III, p. 222.
3. *Ithihas Sangr. Ait. Tipane*, II. p. 53.

the Maratha army in the north, for when once they are disbanded, it would be difficult to collect them again, if they were wanted for service in the North.[1] These were the sentiments of a man from the south. But in the north Mahadji Shinde was not very much in favour of the undisciplined armies composed of the Marathas. Sadashiv Dinkar who stayed with Mahadji Shinde, complains of Mahadji's neglect of the Maratha army from the south and his preference to the disciplined armies who were pampered at the cost of or at least in preference to the Maratha cavalry[2] (1785). Panipat raised so many problems at home that nobody of the Peshwa family could march in person to the north. The politics of the north was entrusted to the Shinde. He does not seem to have entertained any love for his countrymen in the south and won and shared his glory with an altogether different set of people. But the Marathas still took a leading part in the South. For about eleven years of the reign of Madhavrao Ballal the naubat of the Marathas sounded about Poona and the Karnatak. Whether in the civil wars with Raghunathrao and the Bhonsale or at Rakshasabhuwan, Dharwad, Anawdi, wars fought with the inveterate enemies of the empire, the Maratha soldier featured prominently. The successes won in so short a time after Panipat must have meant a very rigorous recruitment from the youth of the country.

Shifting towards the North.

After the civil war, however, waged in revenge for the murder of Narayanrao, the military activity in the south was held in abeyance. No scion of the Peshwa family nor even the head of the administration (Nana Fadnis) could give a personal or an effective lead in any war. Sardars were only second rate leaders from this point of view. Military prowess, in the name of the Marathas was now effective only in the north, Mahadji Shinde being the almost undisputed monarch of that part. That the centre of military power was shifting to the north was evident from the exhibition of helplessness that the Hujarat made, when it became impossible for it to effectively control Raghunathrao without the help of the northern sardars. The Hujarat which formerly was the army led by the Peshwa himself, was later led by Haripant Fadke and was considerably reduced in number. The battles of Wadgaon (1779) and of Kharda (1795) were successful mainly with the help of the sardars. The Mysore War (1790) was carried on only as the allies of the English.

The military spirit of the Marathas seems to have been on the wane since 1774. It was a military state, but it lacked an efficient military leader ; and this deficiency at the centre reflected on all sides.

1. Sane, Patre Yadi, p. 326.
2. *Itihas Sangr. Aiti. Tipane*, V, p. 10.

In the absence of an active ruler capable of inspiring the people with the spirit of enthusiasm, the whole state became anæmic and allowed itself to be hurled into an easy defeat.

This transformation may easily be seen and traced down to the last days of the Maratha empire. We have no time to trace how the Gardies came to be so important in the later days. It will suffice to note their existence immediately after Panipat and the seriously lawless tendencies they represented.[1] The terror in which the Gardies were then held is seen from a letter of Trimbak Baboorao[2] who calls the Gardies '*Para Sainya*', the army (composed) of foreigners. The few lines of Mr. Rajwade on the point of the disaster brought on by the Gardis, especially by their murder of Narayanrao are quite eloquent and instructive.[3]

We have often remarked that the Maratha state, at its foundation and throughout its existence, was bound to be military in outlook. Its best achievements belong to the times when this spirit was weli reflected by its rulers. How they were moulded for war and not for peaceful pursuits has been told elsewhere. In this section an attempt has been made to develop the interplay of this spirit in the history of the Marathas and in the life of the people between 1750-1800.

D. V. KALE

1. Sardesai, III, pp. 235-236.
2. Rajwade, I, p. 389.
3. Ibid., I, Introduction, p. 101.

THE STATE AND THE INDIVIDUAL

The anti-thesis between the State and the individual is conspicuously absent in the thought of the ancients. This distinction is modern and has arisen because of the changed conditions of life. In the City-State man was brought into intimate contact with man in an intensity of life never perhaps since felt.[1] This contact established the recognition of rights and duties and the emergence of a "*res publica*."[2] Human beings cannot long mix together without attempting to define their mutual relations and without seeking to understand their relation to the institutional whole which has made social life possible. A conscious recognition of reciprocal relations is the measure of self-direction acquired by the community and as such constitutes the foundation of freedom. For, self-direction implies that will and purpose, not force,[3] are the bases of the superior and competent power organised under a government. It is will and purpose that impart to political life a moral significance and impress upon it a common import.

The deepest genius that has spent itself on this subject is Plato. He tried to create an adequate sense of appreciation and interest in the myriad-membered life, in the vast discipline of which the individual as a social being and inevitably also as a political being,[4] is involved. "Society," as Nettleship expounds the philosophy of Plato,[5] "depends upon a double fact: the fact that no man is sufficient for himself . . . , and the complementary fact that other men want him. While every man is insufficient for himself every man has it in him to give to others what they have not." This reciprocity is the very root of sociality. The satisfaction of elementary wants is the primary aim of the fellowship to which he belongs. But it cannot be confined to that solely. Otherwise, the life of the people, in such a community, would be little better than that of "a city of pigs."[6] The

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1. In India, on the other hand, man was brought into contact with nature and was impressed with a sense of the inscrutable. The forest sense of things held him in the grip. Cf. Mc. Iver: *The Modern State*, p. 72.

2. See Hetherington & Muirhead : *Social Purpose*, Chap. I.

3. See T. H. Green : *Lectures on the Principles of Political Obligation*, pp. 121-141.

4. Aristotle defines: "Man is naturally a political animal" Weldone, p. 5.

5. *Lectures on Plato's Republic* p..71.

6. Glaucon in *Plato* : *Republic* p. 53,

State continues to exist for good life.[1] The individual is enabled to be what he has in him to become. The mere potentialities imprisoned in him are released by his contact with others in ideal activities. Every individual has a social aspect and the web of man's personality is interwoven by social relations. Personality is evoked and nourished through the interplay of relations and obligations in society. The man whose essence does not include his community with others is a myth.[2] He is real when he shares his life with others. The consciousness that he has a life and a purpose would otherwise be dormant in him. In an ethical sense, such an individual is a mere abstraction, a figment of the imagination. The awareness of himself in a creative fellowship dissolves the illusion of self-and-others. All that makes his life glorious and beautiful grows out of the recognition that his self is only significant as " self-in-and-through-others."[3]

Wherever we have willed and purposed relations, there we have the State, a moral being possessed of a moral life. In this our view, there can be no question of the " sacrifice " of the individual to the State,[4] for both are one in moral purpose. A perfect harmony exists between them.[5] Man, in the Platonic conception, is the micropolis and the city, the citizen writ large.[6] Purpose manifests elements of identity. The individuals are not isolated atoms. The State is the expression of this identity, implying the purpose of more minds than one[7]; the meeting point of minds, not in a temporal but in an ideal sense. The individual, at his best, is himself the whole of the State and of the world; for at his " point " he is the incarnation of the whole; the " point " at which and through which is focussed and vitalised the life-synthesis of the State. " Mind is not an empty point. It is the world as experienced."[8]

The State is, in our view, the highest and best expression of ourselves. It most truly represents us and verily is ourselves. Sir Henry Jones is profoundly true when he said : " The mutual implica-

1. Aristotle : *Politics*, Weldone's Trans. p. 5.
   Cf. Newman's Edition, Vol. I, p. 68 ff.
   Cf. Warde Fowler : *The City-State of the Greeks and the Romans*, p. 59 ff.
   Cf. Bosanquet : *Philosophical Theory of the State*, p. 182.
2. Bradley : *Ethical Studies*, Essay V, " My Station and its Duties," p. 168.
3. M. P. Follett : *The New State*, p. 8.
4. See E. Barker : *Greek Political Thought*, Chap. I, where he argues this problem.
5. See James Seth : *Ethical Principles*, p. 281 ff.
6. Sir Frederick Pollock : *History of the Science of Politics*, pp. 15-16.
7. Bosanquet : *Philosophical Theory of the State*, p. 298 ff.
8. See Sir Henry Jones : *Principles of Citizenship*, p. 80 ff.
   Also : *The Working Faith of the Social Reformer*, p. 48.
   Bosanquet : *Philosophical Theory of the State*, p. 298.

tion of State and citizen has the unity and intensity of a single life".[1] This supreme truth is not generally recognised and understood "even to-day when the social conscience of men has been startled out of its slumber". It is very necessary to grasp the implications of the interdependence of the State and the citizen. "The power of the good State empowers the citizen, and the power of the good citizen empowers the State".[2] The failure to adequately recognise this relationship breeds irresponsibility; "we find it easy to delegate our political and civic duties, reserving for ourselves the luxury of criticising those who perform them". There is a general indifference towards public concerns, and the best fitted content themselves by keeping aloof, forgetting that the penalty is, as Plato long ago pointed out,[3] the evil of being ruled by an inferior.

There are three ways of describing this relationship.[4] The first view regards the State as a means to the development of the individual and insists on the separate life and character of each man. The second view regards the state in itself as the end, and considers that "to its welfare, progress and stability, all right action conduces, and that beside it all other aims and ambitions are insignificant." The third view regards the relation between the citizen and the state "as one between persons, bound together by mutual rights and duties, by mutual responsibilities, and by a common purpose." A careful discussion of these views would lead us to a correct estimate of the State and the citizen and would enable us to understand their mutual relation.

The first view is historically the oldest and can be traced back to Plato and Aristotle. Plato derives society from mutual needs and the division of labour.[5] Aristotle also tells us that the State exists for the happiness of its citizens, and its whole purpose is to secure their welfare.[6] Underlying this view which regards the State as means is the doctrine of the "infinite importance of the individual." The State exists solely for the benefit of its individual members. "Not society but the individual," according to McTaggart, "is the end of social life."[7]

This is a reaction in modern times from the Greek conception of citizenship[8] produced by "the mighty rising tide of circumstance" and

1. *The Principles of Citizenship*, p. 90.
2. Ibid., p. 89.
3. *Republic*, Jowett, p. 25.
4. See Hadow : *Citizenship*.
5. "The City comes into being because, as a matter of fact, each one of us is not self-sufficient but full of wants." (Plato : *Republic* ii. 369).
6. *Politics*, ii. 5, 27 and vii. 9. 1-8.
7. McTaggart : *Hegelianism and Cosmology*, s. 195.
8. The Greek conception of Citizenship is not adequately understood by its critics. We refer the reader to Earnest Barker's *Greek Political Thought*, Zimmern's *Greek Commonwealth*; Dickinson's *Greek View of Life* and Paul Vinogrodoff's *Historical Jurisprudence*, Vol. II.

the influence of the philosophers. Jeremy Bentham formulated the "principle of utility" tending to produce "the greatest happiness of the greatest number." This hedonistic utilitarianism provided the philosophy for individualism during the first half of the nineteenth century. The greatest disciples of Bentham were James Mill and John Stuart Mill. The most characteristic exponent of individualism is, however, Herbert Spencer. The State is looked upon as an opposing element to the individual. "The individual and the State are put over against one another. Their relation is regarded as one merely of antithesis."[1] It is this theory of the individual which seems to underlie Mill's thesis in his famous book *On Liberty*. "Mill, and all those who take up his attitude toward the State, seem to assume that all power gained by the State is so much taken from the individual; and, conversely, that all power gained by the individual is gained at the expense of the State."[2] This is to treat the two elements, the power of the State and the power or freedom of the individual "as if they formed the debit and credit sides of an account book". This implies a mechanical or mathematical view of the relation between the State and the citizen. Moreover, the individual himself is conceived very much in negative terms. His separateness or aloofness from others is taken to be the chief characteristic of individuality. He is more of an individual the less he is like any other individual. In this view individuality amounts practically to eccentricity. The individual is conceived as if he could have meaning and significance apart from his community. The metaphysical aspect of this position is the belief in an abstract individual. There is no clear idea of 'that social whole in whose realisation the false antithesis of "State" and "individual" disappears.'[3] Individualism has not lost its appeal even at the present day. Harold Laski[4] while admitting that "an individual abstracted from society and regarded as entitled to freedom outside its environment is devoid of meaning" posits that the ultimate fact of human experience is that "each of us is ultimately different from his fellows." The individual is real to himself "not by reason of the contacts he shares with others" but on account of the "one unique thing that separates him from the rest of society." "His true self is the self that is isolated from his fellows and contributes the fruit of isolated meditation to the common good which, collectively, they seek to bring into being."[5] "Man is a one among many obstinately refusing reduction to unity. His separateness, his isolation, are indefeasible; indeed, they are so ultimate that

1. Ritchie : *Principles of State Interference*, p. 12.
2. Ibid.
3. E. Barker : *Political Thought in England*, p. 10.
4. *Liberty in the Modern State*, p. 20 ff.
5. Ibid., p. 25.

they are the basis out of which his civic obligations are built. He cannot abandon the consequences of his isolation which are, broadly speaking, that his experience is private and the will built out of that experience personal to himself. If he surrenders it to others, he surrenders his personality."[1] There is much to be said in favour of this view. "Privacy and exclusiveness are evident characteristics of personality."[2] A man's inner life cannot be reached by others and is exclusively his own. As a person he has an excluding personality. 'Whatever forces, whether of the physical or of the human world, play around it and beat upon it, like the waves of the ocean on a rock-bound coast, the "self" is still a sacred realm whose very existence depends on its security against intrusion.'[3] Immanuel Kant had even denied the possibility of the self being an object of knowledge. Admitting the strength of these statements we may yet say that 'if a person *excludes*, he cannot *isolate*; even when he holds the world of men and things at arm's length his intercourse with it remains. His action, after all is interaction. He cannot know if there be no objects to know, and he cannot act except upon them and by means of them. To be free *in vacuo* is to be impotent.'[4] If the self is "the most exclusive and impervious of all that we know," it is also "*potentially the most comprehensive*. It is always the centre, the owner, the user of a world; and he is the most fully and truly a person whose world is widest and richest."[5] Man, in other words, is measured by his world. His self is the centre, the focus, the life of a wider world. The self, as Bosanquet tells us, "is what it includes. It is only finite, imperfect, self-contradictory, exclusive, through the impotence which causes it to include so little. On the other hand, its true nature lies

1. *Liberty in the Modern State*, p. 31.

2. Sir Henry Jones: *The Principles of Citizenship*, p. 58.

3. 'Each self,' we are told, is a unique existence, which is perfectly *impervious* to other selves—impervious in a fashion of which the impenetrability of matter is a faint analogue. The self, accordingly, resists invasion; in its character of self it refuses to admit another self within itself, and thus be made, as it were, a mere retainer of something else . . . The very principle of a self is this exclusiveness . . . The self is in truth the very apex of separation and differentiation . . . It is, in existence, or metaphysically, a principle of isolation. I have a centre of my own—a will of my own—which no one shares with me or can share—a centre which I maintain even in my dealings with God Himself . . . Religion is the self-surrender of the human will to the divine. "Our wills are ours to make them Thine." But this is a *self*-surrender, a surrender which only self, only will, can make.'—Pringle-Pattison's *Hegelianism and Personality*, pp. 216-18. (Quoted by Sir Henry Jones: *The Principles of Citizenship.*)

4. Sir Henry Jones: *The Principles of Citizenship*, p. 60.

5. Sir Henry Jones: Ibid., p. 61.

outside it in the whole, to its dependence on which the defects of its impotence bear witness."[1]

The practical conclusions of individualistic metaphysics are far-reaching. It insists upon a policy of *laissez-faire*. Spencer, the thorough-going prophet of *laissez-faire* would limit the action of the State to the barest minimum. People, if left to look after their own business, are likely to do it best; the intervention of government is an evil; and can only be justified as a remedy against a greater or worse evil.[2] But modern developments have witnessed the increasing encroachments of the " Leviathan". Perhaps, as Bosanquet puts it, " an uncritical individualism is always in danger of transformation into an uncritical collectivism." Every extension of state-action has been a nail in the coffin of *laissez-faire*. The world is rapidly swinging towards Socialism. To it belongs the future. It is a far cry, indeed, from the insistence of the rights of the individual in himself as final to the Socialist State which regards the rights enjoyed by the individual as trusts which can be resumed when emergency arises. The modern mammoth State appears as a huge Leviathan gradually absorbing its citizens into itself. This is, of course, a mistaken reading of present tendencies. Now the spheres of the State and the City on the one side and those of the individual on the other, " have grown together".[3] The State, after all, acts for the individual and by means of the individual; " it organises the powers of its citizens, but it does not annul them." This becomes evident when we examine State and civic undertakings. "All legitimate State or Civic enterprise means the organisation rather than the elimination of individual will; and this in turn means not only more united action on the part of the whole, but more efficient action and a deeper individuality on the part of the members."[4] The individual has "received from state and civic organization a vast accession of strength."[5] The organisation of modern activities, of which the State typifies the highest instance, has placed in the hands of individuals the means of carrying out great enterprises never possible before.

Apart from the question of fact, the relationship between the State and the citizen cannot be adequately understood by reducing the State to a mechanical contrivance. The " State as means " depends upon the view that it exists merely for the sake of the citizens and has " neither meaning nor purpose nor value, not any title to respect, except as a serviceable instrument of their good."[6] This view ignores our

1. *The Principles of Individuality and Value*, p. 325.
2. See Davidson: *Political Thought in England*, Chapter IX.
3. *Philosophical Theory of the State*, p. 70.
4. Sir Henry Jones: *The Working Faith of the Social Reformer*, p. 104.
5. Ibid., pp. 106–107.
6. Sir Henry Jones: *The Principles of Citizenship*, pp. 54-55.

debt to the civic community. "Society without the individual," says F. H. Bradley, "is not more an abstraction than the individual without society." The freedom of isolation is impotence and slavery. The individual "grows with his world". '"Exclusion" or "privacy" is a miserable half-truth.'[1] The views of individualists as well as socialists are fallacious as they regard "the state or civic community, and the individuals who constitute it, as more or less exclusive and independent of each other. The correction of their errors comes from recognising more fully that the State or the City and its citizens have only one life; so that each in repressing its opposite is destroying itself."[2] The State, in this conception, is not a heap nor a machine. "It is," as Bradley rightly says, "the objective mind which is subjective and self-conscious in its citizens; it feels and knows itself in the heart of each."[3]

The Citizen as means: The State as end.—Diametrically opposed to the view we have been so far discussing is the theory which regards the State as an end in itself. The citizens have to think of themselves as servants of the State wishing for nothing better than to contribute to its welfare, if need be by sacrificing their lives. The State is entitled to the highest devotion of the citizens. They must place its welfare and preservation above everything else on earth. "Maintain," says Machiavelli, "the permanence of the State by whatever means you can; they will always be found honourable if the end is secured."[4] The doctrine of the State as end has been promulgated in modern times by Treitschke. "On principle," he says, "the state does not ask how the people is disposed, it commands unquestioning obedience, its laws must be kept whether willingly or unwillingly. It is, no doubt, a step in advance where the tacit obedience of the citizen becomes a rational consent, but this consent is not an absolute necessity." "The State is Power." "Let us remember that the essence of the State is power." 'Treitschke's State tells the poor individual: "It is a matter of utter indifference to me what your feelings are as long as you obey me."'[5] We have an echo of this doctrine in Mussoloni who regards the epithet "sovereign" applied to the people as "a tragic farce". The people are no longer consulted. They are simply "ordered to accept a revolution or a peace or to march into the unknown of war. What power remains to the People? Only to utter the monosyllable which means acquiescence and obedience." Hitlerism seems to be the latest manifestation of such notions; and perhaps, the world

1. Sir Henry Jones: *The Principles of Citizenship*, p. 65.
2. Sir Henry Jones: *The Working Faith of the Social Reformer*, p. 272.
3. *Ethical Studies*, p. 184.
4. See Hadow: *Citizenship*, p. 98 ff.
5. M. A. Mugge: *Trietschke*, p. 40.

has not seen their end. Dictatorships seem to be the reactions against democratic regime.[1]

The doctrine of State absolutism which regards the "State as End" is, in our opinion, very fallacious and imperfect. "A complete surrender of the individual will is not a wholesome condition of human life; it tends on the one side to mechanism and on the other to tyranny; in either case it cramps the intelligence and impedes all growth and progress. Again, though it be true that to regard the State as wholly as means is to encourage personal selfishness, yet to regard it wholly as an end may well encourage in its organs of government a feeling of irresponsibility which is at least equally dangerous."[2]

Before we pass on to the higher synthesis in which the two conflicting views we have been so far discussing can be reconciled, there is one statement that remains yet to be noticed. "In the democratic or humanitarian view," says Hobhouse, "the state is a means. In the metaphysical view it is an end." This is stating the case in a completely abstract fashion.[3] It depends upon the interpretation of the idealist's view of the State "as a totality, which is an end in itself, an end to which the lives of men and women are mere means". It is true that Hegel characterised the State as the absolute power upon earth; "it is its own end." Hobhouse criticises that the method followed by this theory is not ethical.[4] This would imply that Hegel is destroying morality. Nothing can be further from truth. Neither is he suppressing the citizens. His conception of personality, moreover, includes moral freedom. The statement of Hobhouse is not so self-evident as it appears to be. Modern democracies have not ceased to be " metaphysical and the modern States have made large claims on the allegiance of the citizens, and have made them do many things against their will, and even personal ideals." But it is to be realised that " it is not the claims of the state as such but the absolutism of these claims where the false metaphysics comes in." There may not be any incompatibility in the view that regards the State both as a means and as an end. It has been customary to say that " in ancient

1. See Laski: *Democracy in Crisis.*

2. Hadow: *Citizenship,* p. 109. Also Sir Henry Jones: *The Principles of Citizenship,* p. 50. He says:—

"An excessive patriotism, it is believed, is one of the most prolific causes of war and of its ruthless excesses. For the citizens to make their State the object of unlimited devotion as an end in itself seems to bring two intolerable consequences; it involves the complete subordination of their own lives to it, so as to justify its unlimited interference even with their inner or private aspect, and, in a word, to enslave them; and, in the second place, it carries with it the inevitable antagonism of every State to every other State."

3. See Brinkmann: *Recent Theories of Citizenship,* p. 100.

4. *Metaphysical Theory of the State,* p. 20.

society the individual existed for the sake of the State, but that in modern society the State exists for the sake of the individual."[1] The statement is misleading because of its partial truth. The ancient Greeks had a very important sense of the value of the individual,[2] but the individual believed that to separate himself from the State would be his "moral suicide".[3] We may take Athens and Sparta as typical of the Hellenic State. It is true that the Athenian citizen existed for Athens, but Athens, in an equally profound sense, existed for the Athenians. The Athenian citizen would die for Athens, because Athens offered "so glorious a life of freedom to the Athenian citizen." No wonder that Pericles said that the Athenian "needed but to look at his city to fall in love with her."[4] The case of Sparta is only different in a special sense, but Sparta aimed at "the goodness of the individual citizens"; and both Plato and Aristotle regarded her with admiration. The difference between the ancient State and the modern State lies not in that the one was regarded as an end and the other the means, but in the comprehensiveness of the idea of citizenship. The State existed for the citizens alone. The unfranchised multitudes were mere means to the existence of the State.[5] Slavery constituted the basis of Greek democracy. There was no idea that the individual could be at once both a means and an end.[6] The citizens alone were regarded as absolute ends, and the rest were regarded as means. Citizenship in the modern State, at least according to its profession, is for all, and so the modern State may claim to exist for all.

And further, even if we could accept the statement of Hobhouse that the democratic or the humanitarian State is a means ministering to the purposes of its citizens or humanity, could we regard it merely as a means or an instrument? If the State were to be regarded, from the extreme individualist viewpoint, as "anarchy plus the street constable," much more is implied in the existence of the street constable than is apparent at first sight. Through him what Hobhouse has stigmatised as metaphysical is introduced into the constitution of the State in an inexorable way. If the constable could be regarded, in one sense, as a public servant, in another sense, he must be looked upon as distinct and apart from the citizens, because of the possibility of their coming into conflict with the law.

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1. Ritchie: *Principles of State Interference*, p. 100.
2. E. Barker: *Greek Political Theory*, p. 2.
3. James Seth: *Ethical Principles*, p. 283.
4. See the "Funeral Speech", Thucydides: *History of the Peloponnesian War*, pp. 120-128. Everyman's.
5. See Newman: *Aristotle*, Vol. I, p. 138 ff. See also Paul Vinogradoff: *Historical Jurisprudence*, Vol. II, p. 95 ff.
6. Mackenzie: *Manual of Ethics*, p. 336.

This brings us to a discussion of the idealist's view of the relation between the State and the citizen. Both the views that we have been examining so far appear to be logical contradictions, and if forced to draw our conclusion, we would assume that of the two, logically one must be false and the other true. We may be tempted, on the whole, to incline to the view that the State is means, for, we would be naturally reluctant to sacrifice the individual. "The State 'in itself', we say (quite truly), is nothing. But we do not realise that the individual 'in himself' may also be nothing, and that to think of any purpose of either, we must dismiss these abstractions, and endeavour to understand the State and the individual as we find them, not as they might be when severed and held asunder. And the State as we find it is somehow a more or less complete whole, uniting more or less harmoniously, and very greatly enriching the lives of its members".[1] Logically, we said, the two views appear to be irreconcilable. And yet, the demands of creative citizenship require that they shall be reconciled in a higher synthesis. If logic is against us, so much the worse for logic. The relation between the State and the citizen is not a matter for logic or mathematics. It can only be grasped in terms of life, instinct with dynamic principles of growth. "Wherever there is growth, there we must expect to find what will not fit into one or other of the alternatives of an antithesis. No one has solved the puzzle whether the hen or the egg comes first. We cannot understand the one without implying the other; and so it is with the individual and the State".[2]

The State as Personality:—The third view of the relationship between the State and the citizen is that which regards it as one of mutual co-operation and interaction of personalities. They cannot be conceived of except as mutually and organically interdependent. Not only do they share in identity of interest and welfare, but the existence of the one implies the existence of the other. In the absence of either, the other simply disappears. This relationship could be described as a sort of conjunct personality, rooted in the idea of partnership. This partnership is not to be considered, as Edmund Burke, one of the greatest publicists since Cicero tells us, "as nothing better than a partnership agreement in a trade of pepper and coffee, calico and tobacco, or some other low concern, to be taken up for a little temporary interest and to be dissolved by the fancy of parties. It is to be looked on with reverence because it is not a partnership in things subservient to the gross animal existence of temporary or perishable nature. It is a partnership in all science; a partnership in all art; a partnership in every virtue and in all perfection. As the ends of such a partnership cannot be

1. Sir Henry Jones: *The Principles of Citizenship*, p. 5.
2. Ritchie: *Principles of State Interference*, pp. 104-5.

obtained in many generations, it becomes a partnership not only between those who are living, but those who are dead and those who are to be born."[1]

The State, in this view, is a moral or spiritual organism.[2] It is essentially ethical or altruistic. This conception is common to all idealists since Plato first enunciated it.[3] Its noblest exponent in modern times is T. H. Green.[4] It was Hegel specially who insisted that " the State must be envisaged in terms neither of law nor of the morality of individual conscience, but in terms of social ethics ".[5] It is the highest expression of social morality. And this attribution of moral character to the State is not possible " except on the assumption that it is a person ".[6] This attribution of personality has been regarded by some as an unwarranted abuse of metaphor, although great jurists like Gierke and Maitland assert the doctrine of " Real Personality " of the State and other group-persons.[7] We do, indeed, recognise the possibility of serious misunderstandings arising out of our view. Norman Angell, evidently, has good reason to complain against the distortion produced by false analogy.[8] Explanations of life in terms of biological and physical categories of thought are apt to be misleading, because they are half-truths. Society may be more like an animal than a machine, but it is certainly not an animal. Its basis is neither

1. *Reflections on the Revolution in France.*

2. The study of man has been the playground of analogies. Sir Henry Jones rightly warns us against the misuse of metaphors in the human sciences. (See *The Working Faith of the Social Reformer*). And the warning is very necessary. We know how Bluntschli describes the State as a masculine personality, and the Church feminine. (*The Theory of the State*, Bk. I, Ch. I, 7.) Read Ritchie's essay on Social Evolution, in his *Studies in Political and Social Ethics*, and his *Principles of State Interference*, p. 13 ff. The same writer has discussed the problem at greater length in his *Darwinism and Politics*. Theodore Roosevelt discusses the existence of analogies or homologies " as he terms them in human life. See his Romanes Lecture : *Biological Analogies in History*.

3. It rests on the conviction that society and State are self-sown renewing their immortality from age to age. No one might have planned or no one might have planted. But they have " laws of growth all the same ", and their own " grave grandeur ". But the structure of society or the State " is spiritual. It is the product, in every part, of the rational nature of man, and by far the most glorious exhibition of his powers." Sir Henry Jones : *The Working Faith of the Social Reformer*, p. 17.

4. For an exposition of his teaching see Barker : *Political Thought*, Muirhead : *Service of the State*, and Ritchie's Essay on the Political Philosophy, of Thomas Hill Green, in his *Principles of State Interference.*

5. Barker : *Political Thought*, p. 27.

6. Sir Henry Jones : *Principles of Citizenship*, p. 50.

7. Barker : *Political Thought*, p. 175 ff. See also Sabine & Shepard. Introduction to Krabbe's *The Modern Idea of the State*, p. 30 ff.

8. *The Great Illusion*, Ch. VI.

physical nor biological; it is "the rational nature of man", and society is "the product of conscious ends". Human institutions can only be comprehended in terms of the purposes they seek to realise. And yet, there are strange analogies, and even when expressed metaphorically, they might be highly instructive. Thus Plato long ago hinted at, though he did not expressly formulate, the Organic conception of the State. "Is not the best ordered State," he asks, "that which most nearly approaches to the condition of the individual, as in the body, when but a finger is hurt, the whole frame drawn towards the soul and forming one realm under the ruling power therein, feels the hurt, and sympathises altogether, with the part affected, and we may say that a man has a pain in his finger?" The State, in our view, is something more than an organism. Its significance is purposive and is realised through the volition of man. This purposive element cannot be explained by biology. "Acting, living society," according to Bosanquet, "is an infinitely higher thing than a steam-engine, plant, or animal; and the best of our ideas are not too good to be employed in analysing it."

Perhaps, we could best express our implication by describing the State, as we have already done, as a spiritual or moral organism, and attributing to it a personality which is neither quantitative nor physical nor mechanical. It is difficult to define the meaning of this personality, although we vaguely feel what we mean very much when we call the State a "person". We mean that the State is moral, for morality cannot be attributed to "things". Further, the mutual relationship of the State and citizens can only subsist as between persons; otherwise, it would be non-moral, and hence a negation or denial of freedom. In our view, morality implies freedom and is the basis of justice. "There can be no justice", according to Aristotle, "between a man and his chattel".

The State, if it is to be regarded as an organism, must be therefore understood in a very special sense. In an animal organism, the part has no individuality by itself; it is not a "person". But each member of the State is an individual and a person. At the same time, we are also positing the individuality and the personality of the State. This is far more than a fiction of the laws or an abstraction of metaphysics. It is as real as life itself. It is not less real than the individuality and personality of each of its constituent members. It is, indeed, "more real in proportion as its life is fuller and more complete".[1]

It is Hegel who gives the most characteristic exposition of State-Personality and it is he who further states that it is the highest expression, as we have already noticed, of social morality. It is the self-development of the social idea, the self-objectifying of the Universal Spirit.

1. Hadow: *Citizenship*, p. 21.

The individual is realised in the State; he is not a "person" outside of it. His personality reaches to a higher state in the continued and the continuous synthesis of the State. In the same way, the State is itself being gradually realised in the spirit of the world. The personality of the individual is neither sacrificed nor suppressed; and the personality of the State is interdependent on the citizens. The most vital truth of their relationship is this mutuality. The State is nothing apart from its citizens; the citizens, themselves, have no being outside of it. The individual has a supreme value and a sacred destiny. Behind him is the State, an institution that helps to develop his personality; and behind the State is the Spirit, the Eternal Mind reproducing itself in terms of human personality. The whole of the conception is summed up by Green when he said: "God is a being in whom we exist, with whom we are in principle one; with whom the human spirit is identical in the sense that he *is* all which the human spirit is capable of becoming".[1]

The individual has a personality, therefore, only in the State. He is nothing and can do nothing by himself. If his individuality "were stripped bare of all that it has acquired and made part of itself through its participation in the common life *which is possible only within the State*, how much of it would remain?"[2] There is a noble passage in Plato's "Crito"[3] which expresses man's dependence upon the State. "The very existence of the State", as he says elsewhere, "implies that virtue is not any man's private possession. . . . All of us have a mutual interest in the justice and virtue of one another. . . . He who appears to you to be the worst of those who have been brought up in laws and humanities would appear to be a just man and a master of Justice if he were to be compared with men who had no education, or courts of Justice or laws, or any restraints upon them which compelled them to practise virtue".

And so when we attempt to investigate the personality of the individual citizen, we find that its ingredient elements are due to the State and to its manifold institutions. Every shred and element of his personality are "derived from the State in which he has been nurtured."[4] He grows with his world, his mind fills and orders itself; and when he can separate himself from that world and know himself apart from it, then by that time his self, the object of his self-consciousness, is penetrated, infected, characterised by the existence of others. Its content implies in every fibre relations of community. He learns, or already perhaps has learnt, to speak, and

1. *Prolegomena*, p. 198.
2. Sir Henry Jones: *Principles of Citizenship*, p. 93.
3. Jowett: *Dialogues of Plato*, Vol. II, p. 152 ff.
4. Sir Henry Jones: *The Working Faith of the Social Reformer*, p. 277.

here he appropriates the common heritage of his race, the tongue that he makes his own is his country's language, it is (or it should be) the same that others speak, and it carries into his mind the ideas and sentiments of the race (over this I need not state), and stamps them indelibly. He grows up in an atmosphere of example and general custom, his life widens out from little world to other and higher worlds, and he apprehends through successive stations the whole in which he lives, and in which he has lived. Is he now to try and develop his 'individuality', his self which is not the same as other-selves? Where is it? What is it? Where can he find it? The soul within him is saturated, is filled, is qualified by, it has assimilated, has got its substance, has built itself up from, it *is* one and the same life with the universal life, and if he turns against this he turns against himself; if he thrusts it from him, he tears his own vitals; if he attacks it, he sets his weapon against his own heart. He has found his life in the life of the whole, he lives that in himself, 'he is a pulse-beat of the whole system, and himself the whole system.'[1]

Thus we find: "No doctrine of political atomism has ever explained the structure of human society; we are not isolated units in fortuitous concourse, but can co-operate to a common end because we share in a common universal. And it is because this universal is most fully manifested in the State that we can feel towards her a relationship which, not in metaphor but in actual truth, must be described as personal."[2]

Grounds of Political Obligation:—The State thus is not a mere contrivance, but exists to promote good life. Hence it is not morally indifferent. It is, as Hegel tells us in his "Philosophy of Right," the realised ethical idea. It is a completed organisation which makes human life possible. "In the State man has fully realised his outward self to the level of the inward self of thought." It must be envisaged in terms of ethics. We start from a central social system and regard the State as the universal in which each of us as particulars, finding our appointed orbits of duty realise our meaning. To us, therefore, there is no antagonism between the State and the individual; no negative relation of the self to other selves and of the self to the State. The State is thus not external or alien to the nature of the citizen. It is his highest expression; it is the complex of institutions without which, as T. H. Green truly observes, he should not have a life to call his own, nor should be able to ask for a justification of what he is called on to do.[3] It is the basis of fellowship. It is that which raises us from "that abyss of mere animality into which we would otherwise

1. Bradley: *Ethical Studies*, p. 172.
2. Hadow: *Citizenship*, p. 130.
3. T. H. Green: *Principles of Political Obligation*, p. 122

fall." All that we hold dear, science, art, religion, as Hegel says, rest and grow in the State. Outside of it we are left in desolate places, seeking for our home. "The home of the soul," as Follett profoundly observes, "is in the State."[1]

The obedience we, therefore, render to the State, springs from the very facts of our nature, from the very principles of our being. This is not the place to discuss in detail the question of political obligation. We would only say that obligation has its basis in sociality and in the recognition that the State, in the ultimate, most truly represents ourselves. Its performance is not opposed to what we would act in this or that given moment of our lives, but when we are at our best. In obeying the State we obey ourselves. "Self-government is an idea," says Bosanquet, which will "contain the true ground and nature of political obligation."[2] In our view liberty consists in obedience to the law which we have prescribed to ourselves. Law and Liberty are not antagonistic ideas and it is their vital relation that imparts to self-government its profound meaning. The positive conception of the self, as social and as self-in-and-through-others, and a positive relation of the self to law and government would dissolve the paradox implied in self-government in a higher synthesis.

Our statement must not be misunderstood, however, as a justification of the *status quo*. Laski is profoundly true when he says, that our allegiance to the State is only where it commands our conscience.[3] It is purpose that confers validity upon State action. Power is a trust and "is held not for evil but for good, and deflection from the path of right purpose ought to involve the withdrawal of authority for its exercise."[4] For, as Benjamin Constant rightly observes, "No duty would bind us to obey laws which not only restrain our legitimate liberties and limit actions with which they had no right to interfere, but which would also command us to act contrary to the eternal principles of justice and piety."

And the possibility is always there, the possibility of the divergence

1. M. P. Follett : *The New State*, p. 312.
2. Bosanquet : *The Philosophical Theory of the State*, p. 54.

For a more detailed discussion of the problem of obedience, we refer the reader to T. H. Green : *Principles of Political Obligation*; Laski : *Authority in the Modern State, Liberty in the Modern State, Dangers of Obedience, The Problem of Sovereignty*, and *A Grammar of Politics*; Bryce : *Studies in History and Jurisprudence*, Vol. II Essay IX; Ritchie : *Darwin and Hegel*, Essay VII; Bentham : *Principles of Legislation*, Hume : *Essays, A Working Theory of Sovereignty*," by John Dickinson, published in Political Science Quarterly (Two Articles : December, 1927 & March, 1928.) and Vaughan : *Studies in Political Philosophy*, 2 vols.

3. Laski : *Authority in the Modern State*, p. 43.
4. Ibid : p. 46.

between the will of the people and the will of the rulers for the time being, specially when the State is not an all-inclusive partnership. The individual, in our conception, can identify himself with the State and participate in its end, only when he personally shares and interests himself in its governance. If excluded from a share in making the government, " if he cannot, where his fellows choose, be himself made one of the rulers of the State, he is excluded from that which secures him the certainty that his experience counts."[1] No citizen excluded from such participation is free. He cannot, therefore, give his civic acceptance to what his rulers propose. He cannot bring his rulers back " to a realisation of the conditions upon which their power is held."[2]

But, as Laski himself recognises,[3] the right to disobedience is "reasonably to be exercised only at the margins of political conduct". A time may, indeed, come in the history of a people when the maintenance of order might appear to some people as a crime and other things might appear to be more valuable than peace. No government that would run counter to public opinion for any length of time can stand; and if responsible should live constantly in the shadow of its own defeat. Disobedience, however, should not become a settled habit, and there should ever be a due recognition of the individual's indebtedness to the State. Even as Socrates, with the cup of hemlock in his hand, would yet loyally obey the laws, we would regard the State with a spirit of reverence and something of the spirit of Job should animate us:

" *Though He slay me, Yet Will I Trust in Him.*"

PRATAPAGIRI RAMAMURTI

1. Laski : *Liberty in the Modern State*, pp. 37-38.
2. Laski : *Dangers of Obedience*, p. 9.
3. *Grammar of Politics*, p. 62.

THE PLACE OF REASON IN SOCIAL SCIENCES

Faith in reason oscillates between the two extremes, anti-rationalism and over-intellectualism in accordance with the general social temper. Reason, as commonly understood, is paradoxically enough both a reassuring and a doubt-inspiring factor. It is regarded as the supreme faculty of human mind but its supremacy is neither permanent nor evident in everyday experience. Its function in philosophic quarters is generally defined to be quest for truth which is search for certainty; it embarks upon a search for security but it fumbles and hesitates and offers only relative and conditional security. It ventures boldly to understand the true nature of things and stands sceptical considering whether after all it has understood the "true nature"; it propounds a rational scheme for living and the gulf between the actual and the rational appears so astoundingly wide as to make it appear completely utopian. In periods of stress and emotional crisis when the need for security and swift action becomes urgent, the hesitant voice of reason may sound feeble and ineffective. Faith in reason is thus shaken or bolstered up by the total temper in society. Ours is an age of intellectual and emotional crisis. Authority, tradition, intuitive philosophies, theological dogmas—all these are challenged at their foundation and we stand sceptical and even suspicious of the new creeds and dogmas which are at times only the old ghosts masking under a new guise. On the one hand the faith in the established order and security is shaken and on the other the longing for a new order which would promise greater stability has naturally increased. But the gulf between the ideal schemes and the present-day conditions is so great that an average mind turns away from them and seeks refuge in old faiths and dogmas. These general tendencies are bound to influence even the tougher minds of the philosophers and the scientists. Among them the effects of anti-intellectualism which emerged as a protest against the excessive rationalism of the nineteenth century still linger on. Further, frontal attacks have recently been made on the assumed supremacy of reason in the human mind. The long-cherished distinction which man enjoyed as a rational animal is very nearly erased. Recent psychological theories, like psycho-analysis and behaviourism have shown very clearly how meagre a part reason plays in human behaviour. The 'cult of unreason' has, for various reasons, become in some quarters, an intellectual fashion. The danger of such a reaction is not that emotional interests gain ascendancy over

reason, but that it opens flood-gates for the rivals and substitutes of reason—traditional beliefs, authority,—theology, intuitive philosophies etc. The task of reason would become doubly difficult in re-building the foundations of knowledge save for the existence of science and scientific attitude. But even here, in some cases, we find that the repercussions of the general rationalist or anti-rational tendencies are felt. There is a good deal of confusion as to the conception of the nature and function of reason. The long-recurring but very nearly obsolete views about 'reason' are still holding the ground. For instance the two views which assume the antagonism between reason and nature or passions influence even to-day scientific reasoning profoundly. The Kantian view of reason is highly abstract and supernatural. It divorces reason from passions or instinctive elements. The opposing view regards reason as 'a slave of passions' as Hume phrased it. This view finds favour with many recent psychological and philosophical theories. For instance Bergson's distrust of analytic intelligence and mystical faith in the intuitive revelations of instinct exhibit the same tendency, only under a new guise. Whether this divorce of reason and nature is warranted by the facts of experience as explained and interpreted by science is questionable. The controversy between these two views is interminable.

Science arose to discover the nature of things and thus step by step to build the edifice of knowledge. The physical sciences have shown how this edifice could be erected. As Santayana says "the function of envisaging reality, ever since Parmenides and Heraclitus, has been universally attributed to the intellect".[1] The view which disregards experience in general denies at the outset the validity of scientific knowledge because it insists upon *a priori* and supernatural kind of knowledge; whereas the view which regards reason as an instrument of passions would render all knowledge so subjective that it would virtually deny scientific knowledge which is universal and objective. The scientist who deals with human phenomena is handicapped with many difficulties. He has to contend against the forces of anti-rationalism and has to approach his data in an impartial manner. He must put faith in reason *i. e.*, rational inquiry into the nature of social phenomena. But it must be remembered that he is himself a part of the social experience which he investigates; he is to understand and interpret it. It is certain that his mind will be influenced by the conception of reason which he unconsciously holds. In order that his reasoning may not prove to be mere 'rationalization' or a conceptual scheme without any relation to reality, the social scientist must build up an adequate conception of the function of reason in human behaviour.

1. *Life of Reason*, Vol. 1, p. 87.

Modern Psychology has rejected the old hypothesis of the divorce between reason and nature solely because it was an unwarranted assumption. It has, instead, analysed the structure of human mind into root-interests, impulses, desires, emotions, sentiments, intelligence, habits, etc., which make up its fundamental constitution. These various elements are organically related and there is no primary divorce between the life of impulse and the 'life of reasons'. The impulses and desires, with their root-interests are the springs of conduct; emotions and sentiments cluster round these fundamental interests and the objects which satisfy them, thus giving plasticity and effective tone to action. Various habits and sentiments grow up and new interests are built up. But the basic needs lie at the root of all significant human behaviour. They constitute the foundation of the entire net-work of social relationships between individuals and groups which compose society. What is in all this the function of reason? The impulses and desires enjoy a kind of initial independence; "the disarray of human instincts lets every spontaneous motion too far and life seems to oscillate between constraint and unreason." The prime function of intelligence is to elucidate the 'end' or objects towards which an impulse is directed and then to discover means of satisfying it. It thus facilitates the conation of impulse; by giving each impulse its due it attempts to integrate various impulses and interests in such a way that there would be minimum of friction. From each experience it 'learns' and acquires knowledge which would inform subsequent actions. In order to bring about a proper integration, it must understand the nature of end and also of means to be employed for the satisfaction of impulse. New problems and situations arise which it has to grasp and solve. Every time there is a 'problem-situation' intelligence steps in and attempts to solve it. Thus it acquires a 'directive control' over various impulses and interests of mind. As Santayana observes "the sort of imagination that can survey all these interests at once, and can perceive how they check or support one another is called reason." This view of the ideal function of reason does not deny the fact that it is overpowered by passions; rational schemes and ideals are shattered to pieces by the fierce competition of antagonistic interests, either in an individual mind or in society. But it is the function of reason to restore order and balance by recognising definite interests and "to estimate the values of things by that standard". Why there is no such order or harmony either in fundamental interests and their satisfaction or the social relationships based on them and evolved through historical process is the fundamental problem confronting reason—and the social sciences.

But in his endeavour to solve this problem the scientist must keep a proper perspective. When he approaches social data he feels that it

is an incoherent mass of facts and ideals, desires and values—conflicting situations representing 'a flux of things'. It is his business to unravel the underlying elements of order and coherency, if any, and analyse their nature and behaviour. He must realize that initially there is no divorce between facts and values, but that they are organically related. For a systematic understanding of social experience he must, however, select and analyse his facts and judge the nature of the tendencies which lie beneath them. In so far as ideals are operative as 'forces', they are also 'facts' and they cannot be ruled out from his subject-matter of inquiry. The scientist must remember that his principal[1] aim is to understand and analyse but he must not forget that the function of reason is ultimately to[2] 'judge and co-ordinate our interests, to establish a hierarchy of goods and evils, and to value events and persons not by a casual impression or instinct, but according to their real nature and tendency'.

II

The principal aim of the social scientist should be, then, to 'understand the real nature and tendency of social phenomena'. His subject-matter is vast, complex and variable. It has historical continuity and a tendency to change; its nature is organic in the sense that various elements enter into a single event and interact in manifold ways. It includes within its compass the entire gamut of social relationships, events, psychic forces, *i.e.*, ideals, individuals, groups, associations, etc. All these are at times so much confused in reality that the scientist may feel bewildered; but he ventures, like the physical scientist, to discover whether there are any systematic tendencies operative behind the 'apparent chaos'; whether there are any rules or laws which govern human behaviour in any of its aspects. He recognises that all activities are directed towards "something"; there is some objective or end, which may explain the origin or persistence of some of them. The scientist, thus, has to discover the historical or traditional setting, the net-work of social relationships and their interaction in order to appreciate the utility or function of particular social activities. But this involves research into the past events, insight into the present and power to visualize the future. Hence the importance of the historical method and historical science; of the positive or scientific method in analyzing the essential elements governing our behaviour in certain definite ways in order that the origins, causal relations and correlations can be perceived in the ever-changing forms of

1. As Spinoza observes "Wherefore the ultimate aim of man guided by reason, that is, his greatest desire by which he endeavours to moderate all the others, is that whereby an adequate conception is brought to him of all things which can come within the scope of his intelligence". *Ethics*, p. 192. (Everyman).

2. Santayana.

social relations; of the necessary insight which envisages the 'ideal conditions' or 'system of values' towards which the general tendencies move or ought to move.

It would be trite to remark that the social scientist, as a scientist, must be impartial in his inquiry. But there are two points which must be considered here. Firstly it is difficult for a student of social phenomena to make a conceptual distinction between the 'scientific world' and the 'familiar world'.[1] In natural sciences, as Sir A. Eddington argues, the scientist can dispense with his organs of touch, hearing, etc., and can still carry on his scientific inquiry with the aid of one eye. But in social sciences which are mainly observational this is not wholly the case. At times the scientist himself is an efficient instrument in the conduct of his inquiry; he is called upon to feel and understand the facts by a sympathetic 'insight'. The need of a wider social experience is for him always urgent. The danger, here, is that if there is no controlling influence—of method—the scientist may begin to air his personal predilections. Secondly we have to make allowance for the fact that the scientist like other beings in Society is himself the product of social 'mores' and the influence on his mind of particular dominant tendencies of his times may bias his judgment and interpretations. It must be admitted that many a pretentiously scientific inquiry is vitiated by personal bias—for instance, historical investigations or inquiry into contemporary social and economic questions. The so-called scientist would, from this view-point, be regarded as merely a mouth-piece of a particular set of assumptions which he develops with a perfected logical technique. Rational inquiry would, here, amount to nothing but an attempt to justify the unconscious assumptions. It is mere rationalization. But is this position inescapable? If it were, then it would virtually mean a denial of all objective knowledge. Surely we cannot argue that because some people impose their subjective and unconscious impressions on the outside world, all knowledge is subjective or there is no external world. The scientist, qua scientist, is necessarily a realist and postulates the hypothesis of the external world. At the same time it is true that it is through the agency of his mind and through the technique he develops that he can analyse the external world. He deals with his subject-matter—any situation or event—and receives certain impressions which have to be sorted out and critically examined. The problem really is that of '*correct inference*' concerning the nature and behaviour of the external social phenomena. The scientist approaches them with an unbiased mind, receives impressions, which he systematizes, labels and weaves into a conceptual scheme which serves for him as a convenient explanatory hypothesis. Rational inquiry would mean that these "impressions" are not mixed with personal temporary

1. "Physics and Philosophy" in *Philosophy* (January 1933).

moods of the scientist: The impressions which are the raw material for science must, therefore, be controlled by scientific discipline which would give them an objective reality. "Science without pre-suppositions" is as much a necessity in the social sphere as in the physical, if universal knowledge is to be made possible.

The social data are so immense and extensive, so complex and variable that no single science can deal with them adequately. They have biological and psychological basis; they are moulded and changed by the interaction of various tendencies, conscious or unconscious, in society; they are a part of its historical tradition. Thus social data possess various aspects. With the growth of societies a vast array of interests, institutions and associations has arisen. The needs and problems representing the whole net-work of social relationships of the Great society are of such a vast magnitude that several social sciences have undertaken to examine the different aspects of social phenomena. Hence the need for such separate disciplines as history, psychology, economics, politics, jurisprudence, sociology, anthropology, etc. All these have delimited their areas for separate investigations. They use more or less positive or scientific method and their aim is to discover 'laws' or general tendencies which govern human behaviour in those several aspects. Thus "the ideal end is to attain universal[1] statements about partial aspects of all phenomena in a given class." These statements may not be invariable in character; but they may be explanatory and may postulate ideal conditions in which the correlations or causal relations which are inductively established between the two types of phenomena may hold true. This 'isolation' of various aspects is a necessary abstraction because the scientist who undertakes to investigate a limited field would lose sight of his perspective, were he to ramble over alien fields. Further the methodological apparatus which he has developed is necessarily limited to his select 'isolates.' The economist, for instance, conceives the operation of the law of supply and demand obtaining in barter economy and develops the hypothesis of free working of economic factors in ideal conditions, and in the light of this conceptual scheme he attempts to unravel the complex working of economic forces in reality. Every science has to develop some methodological devices in order to get clearer insight into the aspect of things it analyses. It is evident that once the methodological technique is adequately developed there is little danger of subjective intrusion.

There are two main 'instruments of control' which govern the scientist's approach to his data: firstly, the control imposed by 'facts' themselves which compels him to concentrate his attention on understanding their nature and behaviour; secondly, the control of his

1. Morris Cohen: *Reason and Nature*, p. 363.

technique which enables him to select and isolate his facts and analyse them adequately. Both these are inter-connected in any scientific inquiry. The methodological technique is a device to understand the 'facts' and unless it is capable of increasing the perception of the scientists, it is useless; whereas facts in themselves say little or nothing unless there is a theoretical apparatus which analyses or interprets them. Merely historical or descriptive account of facts hardly ever explains their real origin or the causes of their persistence. But social facts possess a historical continuity and unless they are judged in proper historical setting, it would be difficult to grasp their real nature. This, by no means, implies that historical interpretation exhausts all explanation. Moreover, the very word 'interpretation' connotes that historical facts are judged in the light of certain assumptions.

For the social scientist the function of reason, from the point of view of method is fourfold:—

I. The development and classification of primary assumptions necessary for,

II. The formulation of analytical and interpretative technique.

III. Testing of hypotheses and theoretical technique in the light of data presented, and formulation of generalizations or laws.

IV. Interpretation of social phenomena in their wholeness and their relation to the 'system of values'.

I. If clarity and precision are the elementary requirements of scientific scrutiny it is absolutely essential that each Science must clearly state its initial assumptions. They are the starting points of scientific analysis. But they must not be taken as self-evident truths; even they must be challenged, examined and clarified. The scientist must continually be on his guard against unwarranted assumptions which would vitiate his inquiry. He must reject all irrelevant assumptions and retain only those which enable him to gain greater insight into the nature of phenomena under examination. But what are these assumptions? They are of two types: firstly those which are constituted of 'known elements' in terms of which the 'unknown' or a problem is interpreted, that is to say, the scientist would interpret social phenomena in the light of his experience and knowledge. This is best shown by the assumptions which many scientists make about 'human nature'. In all social sciences our assumptions concerning 'human nature' influence profoundly our inquiry and conclusions resulting therefrom. For instance in anthropological investigations the 'Psychological method' has opened up new vistas of intensive research; and it has in recent years certainly contributed more to the formulation of scientific knowledge in that sphere than mere descriptive accounts. But here the validity of conclusions which cumu-

latively constitute the scientific data to work upon depends entirely upon the initial assumptions about human psychology. And these, unless one accepts only what the most up-to-date scientific research in psychology would warrant, reflect the personal experience of the so-called scientist. Racial theories, again, assert much that the geneticist would not dare even to suggest. Hence these 'known elements' in terms of which further research is carried on must be constantly examined and clarified.

II. The other type of assumptions is strictly methodological in character. These are the limiting conditions in the light of which actual social phenomena are viewed and interpreted or they are hypotheses or methodological constructions which explain real situations. But how are these hypotheses arrived at? It must be admitted that they must be developed out of the actual examination of factual data: but this would not exclude the necessity of building up a wider hypothesis, say, for instance, of 'ideal conditions'. The inductively established relationships can be elaborated into logical constructions which would involve deductive reasoning in order to understand actual social facts. This brings us to the question of analytic method. We have seen above that the primary need is the development of correct assumptions both primary and methodological; every science must have its methodological assumptions well-developed. To-day the social sciences are engaged in this task. Each of them is developing an effective technique with which it can examine the special aspect of social facts. It is, simply stated, a logical device to interpret the actual phenomena. The facts must be analysed, inference therefrom verified at each step and hypothesis may be developed which will serve as an 'explanation'. As Santayana[1] observes, "Science expands speculatively by the aid of merely instrumental hypothesis of objects, given in perception until they compose a congruous, self-supporting world, all parts of which might be observed consecutively". This ideal goal is not yet reached; but the social sciences have developed efficient techniques with which actual facts may be handled. Various methods such as the conception of 'equilibrium conditions', 'Comparative method' or 'functional method', method of 'Ideal types' etc., are logical devices to gain deeper insight into phenomena. Reason or intelligence controls this technique and goes on revising and reshuffling it till it is enabled to attain the understanding of the nature of phenomena. It defines its concepts clearly and starts upon the analysis of the given data in their terms. The advance of scientific knowledge depends upon the reduction of unknown to the known elements of facts. And this necessarily involves simplification. Every science whether natural or social has to abstract its data in order

1. *Reason in Science*: Chap. I. 'Types and Validity of Science', p. 15.

to establish 'ideal relations' between correlated phenomena and to judge its real nature. What this means is that as the things stand they express certain relations which on account of other connected phenomena are not actually perceived, or that everything has an ideal development in the sense that the thing, as it now stands, has not expressed its real function or purpose and this has to be discovered. In this sense the analytic technique in its various forms is specifically employed either to establish causal relations or to discover the function or purpose of social relations. We may remember that the larger hypotheses like Marx's 'Dialectical Interpretation of history' or Spengler's hypothesis of 'culture-cycle' are generalizations which need sufficient proof before they could be accepted, and they could hardly be employed as self-evident assumptions in the light of which all social facts may be interpreted. At present each science deals with its partial aspect and is engaged in developing a methodological technique which reveals the real nature of that aspect.

III. The aim of these sciences is to discover the constant elements or the 'efficient purpose' of institutions and social relationships which they embody. Are there any laws which are invariable and which would enable us to predict events?

It is obvious that no one science can predict the tendency of the events as a whole because its analysis and prediction cover only one aspect. But even within the limited sphere is it possible to discover invariable laws? The answer must be: We have to go on and see whether there are any laws or tendencies which govern human behaviour. It is obvious that these laws must emerge from the facts, *i. e.* they must have been inductively established, though for further research they may be refined and modified. Laws of economics state the universal ideal relations between certain aspects of human behaviour which hold perfectly true provided certain conditions are granted. This is the causal relationship. So may it be between certain other types of behaviour, for instance, the effects of economic conditions on political behaviour of a people or State. But before we can analyse the inter-relations of these types of behaviour and establish correlative connections we must analyse the nature and behaviour of social relationships in their several aspects. In analysing the nature and function of institutions we gradually build up a conception of the 'ideal function' which, provided certain conditions are granted, would be realised. This is true particularly in case of the institution of State. We note its function or purpose through historical evolution and then develop the conception of 'ideal[1] function' of state in the light of

1. The function is called 'ideal' because even though its conception is derived from comparative analysis of the institution under review its realization is achieved in an ideal pattern of society.

which the existing states are analysed and judged. From tribal stage (when it could hardly be termed a state) this institution has passed through several phases but through each successive stage we observe a line of evolution. True, an institution never runs through the grooves of uniformity in all societies having varying cultural levels and attainments. But comparative method reveals in the first place the essential components of state in general and secondly fundamental changes in the constitution and function of the state in different phases through the operation of particular forces. Thus in social analysis we discover the nature and function of the state in society. So the social sciences have engaged themselves in two types of inquiries ; firstly, to analyse the nature and function of certain types of social relationships or institutions and secondly, to establish causal relations or correlations in their partial aspects or between the aspects.

And here the need for co-ordination between different specialisms becomes urgent. They may isolate their aspects but when it comes to interpretation, some kind of 'vue d'ensemble' is required so that each aspect may be seen in the light of the whole. The need for developing the 'sociological method' in historical interpretation has been recently emphasised ; and both in political and economic analysis of present-day problems its application has become fruitful of important results. But apart from this the need for some kind of co-ordination is necessary both for clarifying 'assumptions' and interpreting social phenomena in their wholeness. The perspective of this wholeness is the special province of sociology. It clarifies and examines larger hypotheses concerning social phenomena and also co-ordinates the results of different specialisms. Rational interpretation would mean interpretation of facts in their wholeness and this would involve co-ordination of the results of investigations in different aspects of social relationships.

III

Pursuit of Scientific knowledge is a reward in itself. There is no nobler ideal than the disinterested search for truth. Still—a concession to human vanity—one of the aims of scientific inquiry is to attain control over phenomena through the understanding of their nature and behaviour. And this is also the aim of reason: it attains directive control over certain spheres of experience and enriches them. It can achieve this control only through knowledge and hence the need for strict scientific inquiry. But the moral function of science must not be forgotten. The social sciences deal with social phenomena, that is, the whole range of social organisation and its various institutions, with a view to create a rational order in society. If the sciences cannot adequately contribute towards the realisation of this goal, it is not because

they are incapable but because they are not completely developed. Human aspirations and ideals emerge and continually configurate new order of social organisation. The need for newer adjustment manifests itself through conflicts between institutions, associations and ideals. If science cannot give any help in rational reconstruction of the social order, impatient and distrustful attitude towards it is bound to arise. The slow and skeptical approach of science to present-day problems, which demand immediate solution, appears irksome to the lay. There are three main reasons for such an attitude towards social sciences. Firstly they are not sufficiently developed so as to predict the future course of events; secondly even what has been gathered in by reflection and science is not translated into actuality; and thirdly there is little integration between the scientific research—especially in social sciences—and the 'system of values', which envisages a new type of social order. And this disappointment would naturally make us regard reason as a critical, conservative and deadening faculty. Mere scientific analysis is looked upon as a 'barren triumph' when it is not actually harnessed to a purpose. We have again to remember that in reality 'ideals' and 'facts' lie embedded in each other. The ideals which have deep roots in urgent needs or interests have tremendous operative force and their influence must always be counted in looking to what direction the general social relationships are guided. The force of such ideals as 'National State' or 'Imperialism' or 'racial purity' cause big upheavals and give a new shape to existing social institutions. As we see to-day there is a tremendous conflict between ideals—or ideologies as some may phrase it—and the function of reason will be to choose that which increases human happiness to its maximum. But how is this to be achieved? Must science shut up itself in a closet and meditate and disregard the general social tendencies or should it come out boldly and carry its research into the very heart of ideals or ideal schemes which configurate a certain type of social order? Living is a kind of experiment and every deliberate change in society is a fresh venture in pursuit of the ideal of rational life. But this needs analysis and understanding of the actual social institutions and their inter-relations in a particular society; without this scientific knowledge of facts it would be impossible to translate 'ideal' schemes into actual life. The proper integration of 'ideals' and existing facts would be the business of applied science; but it must be informed adequately of the actual problems involved. There must be scientific discipline and insight into the nature of facts. Without this analytic insight, no changes of a permanent nature which would involve a re-adjustment, gradual or catastrophic, of the social order, could be safely effected. It is only this rational insight that could visualize the interrelation between the 'facts' and 'ideals'. The problem to-day is, as Santayana observes, "to unite a

trustworthy conception of the conditions under which man lives with an adequate conception of his interests." Hence the province of social sciences is to study the nature of these conditions and man's interests in their manifold interactions and an adequate appreciation of the fundamental interests of man would be the prime requisite of building up a rational order. The social sciences may not themselves try to bring about the 'unity' in the actual life—at any rate at this stage. But they must attempt to find out what are the existing conditions, their tendencies and necessary manipulations by which unity in social order could be attained. In various departments of life our problems have become enormous and we feel that there must be some order or rational construction so that there may be less conflict. This, we may remind ourselves again, is the function of reason. It discovers ideals, analyses them, seeks their roots in reality and then subjects them to scrutiny in the light of the existing facts which it has studied. Then it may discover the relation between the actual and the rational. Rational life means a pursuit of ideals which gradually emerge out of the felt needs of the community; but before they could be translated into actual life we have to see that they represent the fundamental interests or felt needs of the community and are the genuine expressions of the 'Desires' of people for various things; that the conditions in which they could prosper are controllable and could be manipulated to suit the purpose. Both these require, as we saw in the beginning, an adequate conception of reason, scientific insight into facts and a rational, coherent and realistic system of values.

The social sciences to-day study the interests of man and conditions in which they grow and seek expression in thousand-fold ways within the elaborate frame-work of the Great society. The ultimate aim is to produce a rational order in which there will be more happiness and freedom for the human mind.

RAVI S. BHATT

GENEALOGICAL STUDY OF SOME VITAL PROBLEMS OF POPULATION

To study certain aspects of the problems of population by the genealogical method I selected Vadnagara Nagar community as the class in which I should be able to carry on my research. So I began to study their families and to record dates of their births, deaths, marriages, etc. First of all I had thought of collecting as many facts of as many generations as possible. But by experience I found that so many facts were difficult to be ascertained because the people, on account of their living far away from one another on account of their avocations, did not seem to remember the facts in as great a detail as I would have liked for the purposes of a scientific study. So I decided to pay particular attention to only three generations, a period extending over seventy-five to one hundred years.

Even in this limited enquiry, difficulties did arise; because the people hesitated to give the facts and some of them even refused to give any particulars about their families. It was after a great deal of persuasion that I succeeded in collecting the necessary facts.

Originally I had thought of issuing a questionnaire and getting it circulated in the community. But when I came across the above mentioned difficulties even when I personally approached the people I could see that questionnaire would have proved an utter failure.

Slowly and slowly I made my way and surveyed the families of Vadnagara Nagar Community by the genealogical method at Rajkot. After that I went to Jamnagar. But there I did not get whole-hearted support though I came across some educated young men who promised to help me in my work, which they did to some extent. Then I visited Dhrol, Jodia, Salaya, Khambhalia, Dwarka, Junagadh, Gondal, Jetpur, Bhavnagar, Porebunder. But my work was not fully done on my first visits so I visited Jamnagar, Junagadh, Gondal, and Jetpur thrice.

As to the economic condition of my sample I may mention that it includes middle-class people neither very rich nor very poor, and, as will be seen from the above account, they come from different towns of Kathiawad.

My sample contains 3798 members and 1059 couples of the present generation, 3455 members and 895 couples of the father-generation and 309 members and 151 couples of the grand-father-generation.

I.—AGE AT MARRIAGE.

The following tables give the distributions of age of man and woman in three generations: grand-father, father, and the present generation.

A. Age of Woman at marriage.

(i) Grand-father-generation.

(1) *Frequency Table*

Age at marriage.	Cases.
10	28
11	51
12	65
13	14
	158

Average age :—11·4.

N. B.—All ages are to be understood as completed years. There are 5 cases of double marriage and 1 case of treble marriage of men.

(ii) Father-generation.

(2) *Frequency Table.*

Age at marriage.	Cases.
7	2
8	2
9	6
10	25
11	97
12	316
13	233
14	141
15	72
16	24
17	9
	927*

Average age :—12·7

(iii) Present-generation.

(3) *Frequency Table.*

Age at marriage.	Cases.
10	1
11	8
12	87
13	282
14	294
15	237
16	145
17	38
18	4
	1096†

Average age :—14·2.

* There are 32 cases of double marriage of men.

† There are 37 cases of double marriage of men.

Age of man at marriage.

(iv) Grand-father-generation.

(4) *Frequency Table.*

Age at marriage.	Cases	Age at Marriage.	Cases.
11	4	21	4
12	7	22	10
13	9	23	1
14	20	24	2
15	11	25	1
16	20	26	3
17	20	27	3
18	16	28	1
19	11	29	2
20	6		
	124		27 = 151

Average age :—17·3*

Father-generation.

(5) *Frequency Table.*

Age at marriage.	Cases.	Age at marriage.	Cases.	Age at marriage.	Cases.
9	1	18	105	28	3
10	1	19	102	29	8
11	–	20	109	30	3
12	12	21	71	31	3
13	20	22	87	32	1
14	44	23	43	33	3
15	49	24	26	34	–
16	78	25	18	35	1
17	88	26	9	36	1
		27	9		
	293		579		23 = 895

Average age :—19·1 †

* In the 6 cases of more than one marriage only the age at the first marriage is considered.

† In the 32 cases of double marriage (i. e., second marriage) only the age at the first marriage is considered.

(vi) Present-generation.
(6) *Frequency Table.*

Age at marriage.	Cases.	Age at marriage.	Cases.
15	6	28	4
16	21	29	8
17	46	30	2
18	92	31	2
19	138	32	4
20	184	33	2
21	156	34	2
22	151	35	4
23	106	36	...
24	72	37	1
25	37	38	...
26	15	39	1
27	5		
	1029		30 = 1059

Average age :—21*

From the above tables we find that the average age of woman at marriage in grand-father-generation was 11·4, in father-generation 12·7 and in the present generation it is 14·2.

While the average age of man at marriage in grand-father-generation was 17·3, in father-generation it was 19·1 and in the present generation it is 21.

Thus we see that the average age of woman and of man at marriage is increasing, though it is far from the ideal.

II.—Difference in the Ages of Couples.

The following tables give the distribution of the differences in the ages of couples in three generations :—

* In the 37 cases of double marriage (i. e., second marriage) only the age at the first marriage is considered.

DIFFERENCE IN THE AGES OF HUSBAND AND WIFE.

Grand-father-generation :—

(7) *Frequency Table.*

No. of years.	Cases.	No. of years.	Cases.
0	1	10	4
1	9	11	3
2	10	12	3
3	15	13	1
4	11	14	5
5	13	15	1
6	25	16	2
7	21	17	2
8	10	18	1
9	4		
	129		22 = 151

Average difference :—6·1*

(ii) Father-generation.

(8) *Frequency Table.*

No. of years.	Cases.	No. of years.	Cases.
0	2	12	13
1	26	13	7
2	53	14	10
3	45	15	5
4	92	16	5
5	107	17	6
6	144	18	6
7	123	19	1
8	143	20	1
9	51	21	2
10	34	22	–
11	18	23	1
	820		57 = 895

Average difference :—6·4. †

* For the purposes of the above average the first marriages are taken into consideration.

† For the purposes of the above average the first marriages are taken into consideration.

(iii) Present generation.

(9) *Frequency Table.*

No. of years.	Cases.	No. of years.	Cases.
1	7	13	7
2	30	14	5
3	39	15	5
4	93	16	5
5	156	17	1
6	206	18	1
7	207	19	3
8	162	20	1
9	73	21	4
10	29	22	3
11	6		
12	16		
	1024		35 = 1059

Average difference :—6·7.*

It is seen from the above tables that there is a decided tendency for the difference in the ages of husband and wife to increase, which fact may properly be explained as being due to the fact that owing to the greater spread of education among the males their marriages take place at later ages while the same factor has not operated in favour of the postponement of marriage in the case of females, among whom the spread of education is rather slow.

III.—Age at the Birth of First Child.

The following tables give the distribution of the ages of man and woman at the birth of first child in three generations :—

* For the purpose of the above average first marriages are taken into consideration.

A. Age of woman at the birth of her first child.

(i) Grand-father-generation.

(10) *Frequency Table.*

Age at the birth of first child.	Cases.	Age at the birth of first child.	Cases.
12	1	24	2
13	4	25	3
14	15	26	1
15	28	27	1
16	32	28	1
17	22	29	...
18	20	30	1
19	7	31	...
20	6	32	...
21	4	33	...
22	4	34	1
23	4	35	1
	147		11=158

Average age :—17·59.

(ii) Father-generation.

(11) *Frequency Table.*

Age at the birth of first child.	Cases.	Age at the birth of first child.	Cases.
13	20	31	0
14	122	32	0
15	134	33	0
16	160	34	1
17	144	35	1
18	98	36	1
19	60	37	0
20	36	38	0
21	33	39	0
22	24	40	0
23	9	41	0
24	12	42	0
25	2	43	0
26	4	44	0
27	4	45	1
28	2		
29	4		
30	1		
	869		4=873

Average age :—17·1

(iii) Present generation.

(12) *Frequency Table.*

Age at the birth of first child.	Cases.	Age at the birth of first child.	Cases.
13	2	20	40
14	28	21	16
15	50	22	7
16	101	23	4
17	117	24	3
18	123	25	4
19	78	26	0
		27	3
	506		77 = 583

Average age :—17·52

B. Age of man at the birth of his first child.

(iv) Grand-father-generation.

(13) *Frequency Table.*

Age at the birth of first child.	Cases.	Age at the birth of first child.	Cases.
16	6	30	4
17	7	31	4
18	4	32	2
19	11	33	0
20	12	34	0
21	14	35	2
22	21	36	2
23	14	37	0
24	11	38	0
25	8	39	1
26	8	40	0
27	9	41	0
28	5	42	1
29	4	43	0
		44	1
	134		17 = 151

Average age :—23·57.

(v) Father-generation.

(14) *Frequency Table.*

Age at the birth of first child.	Cases.	Age at the birth of first child.	Cases.
16	19	29	19
17	30	30	19
18	49	31	11
19	55	32	16
20	73	33	5
21	82	34	12
22	98	35	4
23	98	36	3
24	79	37	1
25	72	38	3
26	66	39	5
27	36	40	5
28	30	41	1
		42	3
		48	1
	787		108 = 895

Average age :—23·58.

(vi) Present generation.

(15) *Frequency Table.*

Age at the birth of first child.	Cases.	Age at the birth of first child.	Cases.
18	9	30	8
19	25	31	2
20	31	32	7
21	46	33	5
22	65	34	3
23	72	35	3
24	102	36	2
25	72	37	1
26	55	38	2
27	33	39	2
28	22	40	0
29	15	41	1
	547		36 = 583

Average age :—24·23

From the above tables we find that the average age of woman at the birth of first child in grand-father-generation was 17·59, in father-generation 17·11, and in the present generation it is 17·52, while the average age of man at the birth of his first child in grand-father generation was 23·57, in father-generation 23·58 and in the present generation 24·23.

Thus we see that the average age of woman at the birth of her first child is almost stationary but the average age of man at the birth of his first child has very slightly increased.

IV—Age at the Birth of Last Child.

The following tables give the distribution of the ages of man and woman at the birth of last child in two generations :—grand-father- and father-generations.

A. Age of Woman at the birth of her last child.

(i) Grand-father-generation.

(16) *Frequency Table.*

Age at the birth of last child.	Cases.	Age at the birth of last child.	Cases.
15	1	32	5
16	1	33	5
17	0	34	4
18	1	35	15
19	1	36	8
20	1	37	4
21	1	38	10
22	5	39	4
23	1	40	4
24	2	41	2
25	3	42	5
26	4	43	2
27	6	44	2
28	1	45	1
29	4	46	0
30	3	47	1
31	3	48	2
		49	3
		50	0
		51	1
	38		78 = 116

Average age at the birth of last child :—33·85.*

* Only completed marriages are taken into account i. e., those marriages in which both the partners lived together till the woman reached the age of not less than 40.

(ii) Father-generation.

(17) *Frequency Table.*

Age at the birth of last child.	Cases.	Age at the birth of last child.	Cases.
14	1	33	14
15	1	34	23
16	2	35	25
17	5	36	28
18	0	37	20
19	2	38	27
20	3	39	19
21	4	40	28
22	8	41	14
23	3	42	13
24	6	43	9
25	9	44	6
26	5	45	3
27	11	46	4
28	14	47	2
29	12	48	5
30	6	49	0
31	18	50	1
32	19	51	2
		52	1
		53	0
		54	0
		55	1
	129		245 = 347

Average age at the birth of last child :—34·49.*

* Only completed marriages are taken into account.

B. Age of man at the birth of his last child.

(1) Grand-father-generation.

(18) *Frequency Table.*

Age at the birth of last child.	Cases.	Age at the birth of last child.	Cases.
22	1	43	6
23	1	44	1
24	0	45	6
25	0	46	8
26	1	47	2
27	0	48	2
28	4	49	2
29	4	50	4
30	5	51	2
31	4	52	2
32	1	53	1
33	2	54	2
34	4	55	2
35	3	56	0
36	3	57	2
37	6	58	0
38	4	59	0
39	7	60	3
40	8	61	0
41	5	62	0
42	6	63	0
	0	64	1
		67	1
	69		47 = 116

Average age at the birth of last child :—41·12.*

Only completed marriages are taken into account.

(ii) Father-generation.

(19) *Frequency Table.*

Age at the birth of last child.	Cases.	Age at the birth of last child.	Cases.	Age at the birth of last child.	Cases.
17	1	31	12	45	15
18	0	32	14	46	23
19	0	33	11	47	15
20	0	34	11	48	9
21	3	35	14	49	9
22	1	36	14	50	5
23	4	37	21	51	8
24	0	38	28	52	7
25	1	39	16	53	3
26	4	40	20	54	2
27	4	41	20	55	1
28	3	42	27	56	0
29	3	43	17	57	1
30	4	44	15	58	3
				59	1
	28		240	60	0
				61	1
				62	1
				63	2
					106 = 374

Average age at the birth of last child :—40·31

From the above tables we find that the average age of woman at the birth of her last child in grand-father-generation was 33·85 and in father-generation 34·49.

The average age of man at the birth of his last child in grand-father-generation was 41·12 and in father-generation 40·31.

It will be seen from these figures that reproduction ceases far earlier than what is generally considered to be the physiological limit.

In order to test whether reproductive power had really come to an end at the time indicated by the above tables, the cases of completed marriages were further analysed with a view to determining if a sufficient number of years had elapsed after the birth of the last child during which couples continued to be in a married state. It will be seen from the following tables presenting this analysis that in the

* Only completed marriages are taken into account.

grand-father-generation in the cases of completed marriages in which both the partners were alive for seven or more years after the birth of the last child woman lived on an average for 23 years and in the father-generation for 19 years.

Average number of years which a woman lived after the birth of her last child.

(1) Grand-father-generation.

(20) *Frequency Table.*

No. of years woman lived after the birth of last child.	Cases.	No. of years woman lived after the birth of last child.	Cases.	No. of years woman lived after the birth of last child.	Cases.
7	4	22	1	37	3
8	1	23	2	38	0
9	2	24	1	39	0
10	3	25	1	40	0
11	3	26	4	41	1
12	6	27	3	42	1
13	4	28	4	43	1
14	4	29	4	44	1
15	4	30	4	45	0
16	1	31	3	46	1
17	1	32	5	47	1
18	4	33	2	48	1
19	3	34	3		
20	3	35	2		10 = 95
21	2	36	0		
	45		40		

Average number of years which a woman lived after the birth of her last child :—23·1.*

* Only the cases of completed marriages in which both partners lived for seven or more years after the birth of their last child are taken into account.

(ii) Father-generation.

(21) *Frequency Table.*

No. of years woman lived after the birth of last child.	Cases.	No. of years woman lived after the birth of last child.	Cases.	No. of years woman lived after the birth of last child.	Cases.
7	13	22	5	37	1
8	17	23	8	38	1
9	17	24	7	39	2
10	7	25	9	40	2
11	9	26	4	41	0
12	8	27	8	42	2
13	9	28	12	43	3
14	14	29	4	44	0
15	20	30	8	45	1
16	16	31	3	46	0
17	7	32	2	47	0
18	17	33	4	48	1
19	14	34	3	49	0
20	15	35	0	52	1
21	11	36	4	54	1
	194		81		15 = 290

Average number of years which a woman lived after the birth of her last child :—19·3.*

* Only cases of completed marriages in which both partners lived for seven or more years after the birth of their last child are taken into account.

Average number of years which a man lived after the birth of his last child.

(i) Grand-father-generation.

(22) *Frequency Table.*

No. of years man lived after the birth of last child.	Cases.	No. of years man lived after the birth of last child.	Cases.	No. of years man lived after the birth of last child.	Cases.
7	2	22	4	37	5
8	1	23	2	38	5
9	1	24	4	39	2
10	2	25	3	40	0
11	0	26	2	41	1
12	3	27	5	42	0
13	2	28	4	43	1
14	1	29	2	44	2
15	3	30	6	45	1
16	3	31	1		
17	2	32	4		
18	3	33	4		
19	1	34	4		
20	3	35	0		
21	3	36	3		
	30		48		17 = 95

Average number of years a man lived after the birth of his last child :—26·3*

* Only cases of completed marriages in which both partners lived for seven or more years after the birth of their last child are taken into account.

(ii) Father-generation.

(23) *Frequency Table.*

No. of years man lived after the birth of last child.	Cases.	No. of years man lived after the birth of last child.	Cases.	No. of years man lived after the birth of last child.	Cases.
7	17	22	6	37	0
8	22	23	7	38	0
9	17	24	7	39	1
10	11	25	10	40	2
11	12	26	2	41	0
12	5	27	7	42	1
13	14	28	10	43	3
14	16	29	9	44	0
15	21	30	4	45	1
16	17	31	3	52	1
17	6	32	3		
18	15	33	3		
19	12	34	1		
20	13	35	0		
21	7	36	4		
	205		76		9 = 290

Average number of years which a man lived after the birth of his last child :—17·9.*

From these facts it becomes clear that the ages at the birth of last child indicated in the tables Nos. 16, 17, 18, 19, do really mark the end of reproductive period.

In view of the fact that the end of reproduction occurs very early in the case of both man and woman a question arises as to whether this early cessation of reproduction is due to the exhaustion mainly of woman or man. To shed some more light on this problem thirtytwo cases of double marriages in father-generation have been analysed. Being cases of second marriage none of them happens to be a completed marriage. In one case the husband died very early. Leaving this case out it is found that the woman's age at the birth of her last child is 27·16 while the man's age is 42·06. It is further found that on an average 6·8 years have elapsed since the birth of the last child. We may therefore reasonably assume that in these thirtyone cases also reproduction has nearly come to an end. It is seen that in this sample the woman's age at the birth of last child falls short of the age at the

* Only cases of completed marriages in which both the partners lived for seven or more years after the birth of the last child are taken into account.

birth of last child in general sample by nearly 7 years, while man's age in this sample is higher than man's age at the birth of last child in the general sample only by two years. It may therefore be submitted that cessation of reproduction at such an early age as is indicated in the first part of this section is perhaps due more to the exhaustion of man than of woman.

The following table gives the frequency distribution of 32 cases above referred to :—

ANALYSIS OF THIRTY-TWO CASES OF DOUBLE MARRIAGES IN FATHER-GENERATION

(24) *Frequency Table.*

Age of man at the birth of his last child.	Cases.	Age of Woman at the birth of her last child.	Cases.	No. of years both partners lived after the birth of their last child.	Cases.
30	2	17	1	1	6
31	0	18	1	2	4
32	0	19	1	3	2
33	1	20	0	4	3
34	1	21	1	5	4
35	1	22	1	6	1
36	1	23	4	7	0
37	0	24	2	8	0
38	2	25	4	9	2
39	3	26	0	10	0
40	0	27	1	11	1
41	3	28	4	12	0
42	2	29	3	13	1
43	1	30	0	14	1
44	2	31	1	15	0
45	1	32	0	16	1
46	5	33	1	17	0
47	0	34	1	18	2
48	1	35	3	19	1
49	1	36	1	21	1
50	1	40	1		
51	3				
	31		31		30

Average of thirtyone cases of second marriages where both partners are living: Age of man at the birth of his last child 42·06. Age of woman at the birth of her last child 27·16. The average period elapsed since the birth of last child is 6·86 years.

V.—FECUNDITY OF MARRIAGE.

The following tables give the distribution of the fecundity of couples in two generations :—Grand-father- and father-generations.

Average fecundity of marriage.*

(i) Grand-father-generation.

(25) *Frequency Table.*

No. of births.	No. of cases.	Cases. of twins.
1	4	
2	6	
3	11	
4	12	
5	15	
6	22	1
7	23	1
8	8	2†
9	8	3
10	3	
11	2	
12	2	
	6	7

Average fecundity :—5·83

(ii) Father-generation.

(26) *Frequency Table.*

No. of births.	No. of cases.	Cases. of twins.
1	28	
2	14	
3	20	
4	42	
5	39	
6	80	1
7	56	1
8	41	1
9	23	4‡
10	11	
11	11	1
12	5	1
13	4	
	374	9

Average fecundity :—5·95

From the above tables we find that the average fecundity of marriage was 5·83 in the grand-father generation and 5·95 in the father generation.

VI.—INTERVAL BETWEEN TWO CONSECUTIVE BIRTHS.

The following tables give the distribution of the intervals between two consecutive births : issues of the couples of three generations :—grand-father, father and the present generation.

Interval between two consecutive births :—

* Only completed marriages are taken into account, i. e. those marriages in which both the partners live together till the woman reached the age of 40.

† A case of two twin births. ‡ Three cases of two twin births.

(i) Grand-father-generation.
(27) *Frequency Table.*

Interval in years between two consecutive births.	Cases.
1	7
2	151
3	256
4	171
5	50
6	16
7	5
8	2
9	0
10	2
	660

Average interval between two consecutive births :—3·3.

(ii) Father-generation.
(28) *Frequency Table.*

Interval in years between two consecutive births.	Cases.
1	58
2	723
3	1301
4	717
5	162
6	44
7	18
8	15
9	2
10	3
11	1
12	0
13	0
14	1
15	0
16	1
	3046

Average interval between two consecutive births :—3·17.

(iii) Present generation.
(29) *Frequency Table.*

Interval in years between two consecutive births.	Cases.
1	12
2	152
3	293
4	202
5	46
6	16
7	8
8	4
9	1
10	1
11	0
12	3
	738

Average interval between two consecutive births—3·3.

From the above tables we find that the average interval between two consecutive births among the issue of grand-father-generation was 3·3, among those of father-generation 3·2 and among those of the present generation 3·3.

VII.—Child Mortality.

The following tables give the distribution of mortality among children born to couples of three generations:—Grand-father, father and the present generation.

Mortality among children under five years of age per 1,000 children born.

(i) *Grand-father-generation.*

Total No. of births.	Miscarriages.	Total No. of children born.
824	20	804

No. of children dead under five years of age:—164.

Rate of child mortality under five years of age per 1,000 children born:—228·85.

(ii) *Father-generation.*

Total No. of births.	Miscarriages.	Total No. of children born.
4,018	164	3,854

No. of children dead under five years of age:—884.

Rate of child mortality under five years of age per 1,000 children born:—229·37.

(iii) *Present-generation.*

Total No. of births.	Miscarriages.	Total No. of children born.
1,372	103	1,269

No. of children dead under five years of age:—304.

Rate of child mortality under five years of age per 1,000 children born:—239·55.

From the above tables we find that the average mortality under five years of age, among children born to the couples of grand-father-generation was 228·85, among those born to the couples of father-generation 229·37 and that among children born to couples of the present generation 239·55.

Thus we see that child mortality has increased.

VIII.

The following tables give the distribution of the ages at death of man and woman in two generations: grand-father, and father-generations.

A. Grand-father-generation.

(i) Age of woman at death.

(30) *Frequency Table.*

Age at death.	Cases.	Age at death.	Cases.	Age at death.	Cases.	Age at death.	Cases.
16	1	33	2	51	2	69	0
17	1	34	1	52	2	70	3
18	3	35	1	53	4	71	0
19	0	36	3	54	4	72	1
20	0	37	2	55	3	73	1
21	0	38	2	56	4	74	1
22	2	39	2	57	3	75	1
23	2	40	7	58	4	76	1
24	0	41	5	59	1	77	1
25	0	42	3	60	4	78	0
26	2	43	1	61	4	79	1
27	0	44	0	62	2	80	0
28	0	45	8	63	5	81	1
29	1	·46	5	64	4	82	0
30	1	47	4	65	2	83	0
31	2	48	2	66	4	84	1
32	2	49	5	67	0	0	0
		50	6	68	0	0	0
	17		59		52		12=140

Average age at death :—49·4.

N. B.—**18 women are living who are therefore not included in this table.**

(ii) Age of man at death.

(31) *Frequency Table.*

Age at death.	Cases.	Age at death.	Cases.	Age at death.	Cases.	Age at death.	Cases.
23	1	41	0	58	3	75	6
24	0	42	0	59	1	76	0
25	0	43	2	60	4	77	2
26	1	44	4	61	1	78	0
27	0	45	4	62	5	79	1
28	0	46	4	63	4	80	4
29	1	47	0	64	5	81	1
30	2	48	1	65	6	82	1
31	1	49	6	66	3	83	2
32	1	50	6	67	4	84	2
33	1	51	2	68	2	85	0
34	0	52	3	69	1	86	1
35	1	53	1	70	5		
36	0	54	7	71	2		
37	1	55	4	72	4		
38	1	56	4	73	3		
39	1	57	0	74	4		
40	0						
	12		48		57		20=137

Average age at death :—59·4.

N. B.—14 men are still living who are therefore not included in this table.

B.—Father-generation.

(i) Age of woman at death.

(32) *Frequency Table.*

Age at death.	Cases.	Age at death.	Cases.	Age at death.	Cases.	Age at death.	Cases.
13	2	30	10	47	4	65	2
14	4	31	7	48	2	66	0
15	7	32	4	49	3	67	0
16	5	33	11	50	1	68	0
17	9	34	14	51	1	69	0
18	7	35	6	52	2	70	1
19	4	36	6	53	4	71	0
20	7	37	3	54	5	72	1
21	7	38	7	55	1	73	0
22	4	39	4	56	1	74	0
23	8	40	7	57	0	75	0
24	9	41	5	58	1	76	1
25	14	42	6	59	4		
26	6	43	3	60	3		
27	3	44	6	61	0		
28	14	45	6	62	1		
29	0	46	8	63	0		
				64	1		
	110		113		34		5 = 262

Average age at death :—33·4.

N. B.—665 women are still living who are therefore not included in this table.

(ii) Age of man at death.

(33) *Frequency Table.*

Age at death.	Cases.	Age at death.	Cases.	Age at death.	Cases.	Age at death.	Cases.
15	1	33	5	50	14	68	1
16	0	34	5	51	6	69	1
17	1	35	5	52	9	70	3
18	2	36	3	53	3	71	1
19	4	37	5	54	8	72	1
20	8	38	6	55	3	73	0
21	2	39	3	56	3	74	0
22	2	40	8	57	6	75	2
23	5	41	6	58	5	76	0
24	5	42	7	59	8	77	0
25	2	43	5	60	8	78	0
26	5	44	9	61	3	79	1
27	5	45	8	62	2	80	
28	5	46	7	63	4		10=266
29	4	47	2	64	2		
30	5	48	6	65	5		
31	2	49	7	66	1		
32	8			67	3		
			97				
	66				93		

Average age at death :—43·9

N. B.—629 men are still living who are therefore not included in this table.

From the above tables it is seen that the average age of woman at death in grand-father-generation was 49·4 and that of man in the same generation was 59·4.

While the average age of man at death in father-generation was 33·4 and that of man in the same generation was 43·9.

It will not be fair to draw any conclusions about the change in longevity in the two generations studied. For, first of all in spite of repeated attempts to get information about the brothers and sisters of the men and women of the grand-father-generation I have not succeeded in getting the necessary information. The sample, therefore, of the grand-father-generation is small and perhaps also selected. Secondly, far too many men and women of father generation are still living. The following tables will give an idea as to the number and average ages of these men and women.

A.—Grand-father-generation.

(i) Age of woman still living.

(34) *Frequency Table.*

Age of woman still living.	Cases.	Age of woman still living.	Cases.
55	1	73	0
59	1	74	0
60	1	75	1
61	2	76	0
62	2	77	0
63	0	78	1
64	0	79	0
65	2	80	1
66	1	81	0
67	1	82	0
68	0	83	0
69	0	84	0
70	1	85	0
71	0	86	0
72	2	87	0
		88	1
	14		4 = 18*

Average age of woman still living :—67·7.

(ii) Age of man still living.

(35) *Frequency Table.*

Age of man still living.	Cases.	Age of man still living.	Cases.
65	2	75	0
66	2	76	1
67	1	77	0
68	0	78	0
69	0	79	1
70	2	80	0
71	1	81	0
72	2	82	0
73	0	83	0
74	1	84	1
	11		3 = 14

Average age of man still living :—71·2.

* Of these 13 are widows.

B.—Father-Generation

(i) Age of woman still living.

(36) *Frequency Table.*

Age of woman still living.	Cases.	Age of woman still living.	Cases.	Age of woman still living.	Cases.
16	2	34	22	54	16
17	2	35	14	55	12
18	5	36	25	56	9
19	1	37	14	57	4
20	5	38	20	58	12
21	5	39	22	59	10
22	5	40	33	60	7
23	7	41	23	61	7
24	12	42	16	62	10
25	5	43	34	63	7
26	11	44	18	64	1
27	6	45	23	65	5
28	10	46	17	66	4
29	20	47	12	67	1
30	22	48	26	68	2
31	8	49	12	69	1
32	14	50	19	70	2
33	20	51	11	71	1
		52	13	72	0
		53	10	73	0
				77	1
	160		393		112=665*

Average age of woman still living :—41·7

* Of these 51 are widows.

(ii) Age of man still living.

(37) *Frequency Table.*

Age of man still living.	Cases.	Age of man still living.	Cases.	Age of man still living.	Cases.
16	1	35	7	56	16
17	0	36	8	57	13
18	0	37	14	58	13
19	0	38	16	59	10
20	1	39	19	60	11
21	0	40	20	61	9
22	1	41	25	62	9
23	0	42	23	63	7
24	3	43	18	64	12
25	5	44	16	65	6
26	2	45	24	66	5
27	3	46	28	67	4
28	3	47	29	68	7
29	5	48	38	69	3
30	6	49	15	70	4
31	6	50	29	71	1
32	5	51	28	72	3
33	10	52	22	73	2
34	12	53	24	74	1
		54	7	75	0
	63	55	16	76	1
				77	1
			426	78	1
				82	1
				84	
					140=629

Average age of man still living :—47·9.

From the above tables we see that the average age of woman of grand-father-generation still living is 67·7 and that of man still living of the same generation is 71·2.

While the average age of woman of father-generation still living is 41·7 and that of man still living of the same generation is 47·9.

It may be surmised from this that the average age at death of man and woman of father-generation could not be so low as is indicated in the tables 32 and 33. For a proper comparison between the two generations in respect of longevity we must wait. It is hoped that a further enquiry into the details of the living members of father-generation may be undertaken fifteen years hence. Only then can a proper comparison be instituted,

B. L. MANKAD

THE SPIRIT OF SWADESHISM

To those of us in India who have followed the growth of the Swadeshi movement during the last few years it is a truism that it is the manifestation of a deeply rooted nationalism in the field of economics. To many of us it is likewise apparent that economic nationalism as it exhibits itself to-day in the world has two aspects. There is an economic nationalism of a militant type, aggressive in character, and ready in the last resort to substitute force where other influences fail. But there is also an economic nationalism of a healthier type, rooted on foundations of the spirit whose fruits may ripen in a country like ours earlier than in other lands, if the spiritual forces awakened by the Saint of Sabarmati and the prisoner of Yeravda gather strength.

The militant nationalism of our times was born of a combination of circumstances, dating back to the individualism of the fifteenth and sixteenth centuries in Europe. That individualism was a protest against the dead vestiges of the feudal times ; it was voiced through the economic and political theory of the 17th and 18th century philosophers and it was translated into laws and institutions—associated with the family, the laws of inheritance and succession, the right of unlimited acquisition, and the sanctity of contracts. With the rise of industrialism, and the growing importance of capital in economic life, economic nationalism manifested in the field of international relations the play of the same competitive forces which the *laissez faire* theorists had glorified as the basis of prosperity and the instrument of progress. It led to the evolution of armaments and culminated in the horrors of 1914–1919, when the nations of the world born and bred in traditions of hatred turned God's earth into a slaughter house of the innocents. But the war did not end this militant nationalism. Nationalism of the militant type is as fatal to human welfare when applied to the field of economics as it is when it manifests itself in the building of dreadnoughts and submarines and tanks.

To-day this militant nationalism is clearly manifest in the tariff walls which have broken European commerce more effectively than ever the mountains and the raging torrents divided the tribes of ancient Greece.

The history of European diplomacy after 1919 is a continuation of the diplomacy of pre-war days, though it may disguise itself in the polished language of peace and goodwill in the Hall of the assembly of the League of Nations. The French occupation of the Ruhr, the

internationalisation of the Saar basin under the administrative control of France, the mandates in Syria and in the German colonies in Africa, are varnished replica of the partitions of Poland in the 18th century and the partition of Africa in the 19th.

The monetary policy of the European countries since 1931 is equally an expression of this militant nationalism. The countries that went off the Gold standard in that year and later so did not do, out of a disinterested conviction of the uselessness of the yellow metal for monetary purposes; they did so because they were afraid that adherence to a free market in Gold under the Gold standard would involve a depletion of their Gold resources so essential for the building of armaments and in the crisis of war.

Contrasted with this militant nationalism is a healthier economic nationalism rooted in a desire for national self-expression in the field of economics which can blossom out into a co-operative commonwealth of naticns linked increasingly closer by the mutual exchange of commodities—a voluntary exchange of economic surpluses. This *nationalism* is rooted in love and co-operation. By being national in this sense, we are not shutting ourselves in by shutting others out. The cult of *Swadeshi* is to be for us the stepping stone, the indispensable stage of national self-respect, on which we can rise into the larger life of international co-operation and commerce, not under the stress of circumstances forced on us by the accident of conquest, but of our own free will, giving unto the world not merely the material goods which dwindle by exchange but the gifts of the spirit which grow by being shared. There is another phase of this very argument, which we may also keep in view. The life of nations is not unlike the life of individuals. So long as the individual is economically dependent on another, he lacks the material opportunities for leisure and freedom which are so intimately associated with the fullness of life. So also the nation that is economically dependent on others is lacking in the opportunities for national self-expression.

If the India of the future is to take its place as an equal partner in the family of nations, it can only win that place by economic planning in the first instance directed to its own interests: and the cult of Swadeshi is only another name for the response on the part of the social environment to the economic planning started by the organism. Or, shall we rather say that the cult of Swadeshi is the stimulus on the part of the social environment that will call forth national economic planning on the part of a free India of the future?

Humanity to-day is at the cross roads—the choice is between a militant nationalism, sometimes assuming the larger proportions of a militant Imperialism seeking for security through armaments, each

seeking security by making the lives of others insecure, and a healthier nationalism risking its security in a spirit of adventure, struggling through an adverse environment into a new national existence, in order that the heritage of love and good will which it has re-discovered through its national existence may become the common possession of mankind. For, both in the world of matter and of the spirit, it is intangibles and imponderables that rule, not the rattling sword, nor the multiplicity of commodities, nor the bombs thrown from æroplanes nor the possession of gold and silver, but the energies that sway the heart and the emotions and feelings of sympathy and love. And let us hope that the *Swadeshi* for which we stand to-day in India is inspired by that imponderable that men call love and that we are assigning to this spirit of love the task of unravelling the mysterious complex of ethnology and history and economics which make up the passions and misunderstandings and also the possibilities of the greater India that belongs to the future.

We have been accustomed to speak of the structure of modern civilisation. Civilisation is the art of living together for the purposes of the fullness of life. Let the cult of *Swadeshi* be for us the invisible mortar that holds together the house that we build—and we build it not for ourselves alone. Our house will be the market place for the nations of the world, for our home is the world, linked into a corporate unity by ties of love and friendship, resting its exchanges on principles of justice and equity. You and I may not live to dwell in this house, enough for us that we contribute our labour to its upbuilding so that others may live in it, enough for us that we are co-workers with God in the construction of this temple of human commerce, where the nations hereafter may come to worship *Swadeshi* as the symbol of sacrifice and service—and to feel that it is the Lord who has helped in the building of this temple. For except the Lord build, their labour is in vain that build it.

P. A. WADIA

A SUMMARY SURVEY OF THE ECONOMIC LIFE OF AN ABORIGINAL TRIBE OF GUJERAT

Economic Heritage and Life of the Chodhras of Gujerat

The physical environment forms generally the basis of economic activity. The aborigines occupy at the present day the hilly and forest regions of India, especially the Vindhya and Satpura Ranges and the Ghauts. The Chodhra tribe with a population of 45,000 occupies the South-East portion of Gujerat—the Mandwi and Bardoli Talukas, and the neighbouring territories of the Baroda and Rajpipla States. The major portion of the tribe is to be found in the Mandwi Taluka (about 70% of the entire population of the place) in the North-East of Surat District, lying between $21^{0}12'$ and $21^{0}27'$ in the N. and $72^{0}59'$ and $73^{0}29'$ in the E. Here the Satpura Ranges meet the Western Ghauts and the Tapti flows on its westward course.

The surface of the territory covering 279 sq. miles and 153 entire villages including 55 sq. miles of forest is throughout rugged and broken, cut up by small streams and interspersed by mounds of rising ground. The forest area which covers 25 villages, and indeed the whole taluka, is covered with trees. The trees include the sag (tectona grandis), kher (acacia catechi), sadra, tanas, bunyan (ficus indica), pipal (ficus religiosa), babul (acacia arabica), limbdo (melia azadirachta) champa (michelia champaka), bordi (zizyphus jujuba), mowra (bassia latifolia), date (phœnix sylvestris), brab, tamarind (tamarindus indica), mango and a large number of creepers and wild plants locally known as billi, kakdo, kubija, umarda, bibi, umbhe, jamne, hore, gunde, bure, gagde, tatire, talphade, chakine, bio, kamboi, karvat, girmalo, bero etc. The fruits of many of these are edible, and they are eaten raw or made into pickles or cooked for festival meals.

The forests and jungles of Mandwi are the homes of many wild animals and thirty years ago they were infested by panthers who were a source of constant danger to the people. The panther is deified in almost all the forest villages as vagh-deo. The chief animals in the forests at present, and the potent enemies of the farmers are the wild boar and the monkey. The monkeys are purely vegetable feeders, their food consisting of wild fruits and grain. These are said to be responsible for the destruction of a large portion of the crops every year. The other animals in the forests are jackals, wolves, hyena, foxes, deer and rabbits. Reptiles, including the cobra, are found in

large numbers in the forests; but they are rarely seen in the villages. The people never kill them on account of religious superstition.

The following is a list of animals, mostly wild, which are known to the villagers:

Primates:

The monkey (macacus)

Carnivora:

The panther (Filis pardus)
The bear (small and black)
The hyena
The fox (vulpes bengalensis)
The jackal (canis sureus)

Rodentia:

The squirrel
The hare (lepus nigricollis)
Cat (wild)
Tiger-cat
Rat (mus rattus)
The mongoose

Ungulata:

Wild horse
The antelope (Antelope bezoorbea)
The deer (cervidæ)
Wild goat
The wild boar (sus cristatus)

Batrichians:

Frog
Skink

A large variety of birds with coloured plumage, wild and water fowls, are found in the forest areas, especially near tanks, rivers and streams. They include crows, jays, swallows, larks, wood-peckers, cuckoos (with and without crests), owls, kites, jungle-fowls, herons, plovers, coppersmiths, vultures, storks, kingfishers, parrots, sparrows etc.

The contact with towns, the clearing of forests for the purposes of cultivation and the protection of forest areas by the State have at present driven the wild animals inland into the deeper forests of the surrounding States, with the exception of the wild boar and the monkey which are still left to ravage the fields of the cultivators.

The climate of a place, determined by the temperature of the lower strata of the air, by the degree of moisture contained therein, the form and quality of its precipitations, and its distribution throughout the year, should be noted together with the flora and fauna of a place, as it vitally affects the economic activities of a people. The hot months at Mandwi are May and June, and March and April to a lesser extent. The cold months are December, January and February. The temperature varies between 44^0 and 114^0 F. which are the minimum and maximum temperatures recorded at the Govt. Dispensary at Mandwi between 1928 and 1930. I was able to record 35^0 F. at the village of Sathvav on 29th Dec. 1928 at 3 A. M. The maximum and minimum temperatures during the twelve months of 1930 were as follows:

Month.	Maximum.		Minimum.		Month.	Maximum.		Minimum.	
	7 a. m.	3 p. m.	7 a. m.	3 p. m.		7 a. m.	3 p. m.	7 a. m.	3 p. m
January ...	75	98	46	73	July ...	80	88	69	80
February ...	66	100	44	77	August	78	93	67	80
March ...	76	104	60	95	September	71	91	65	78
April ...	85	108	70	98	October	80	101	66	81
May ...	84	106	78	97	November	72	98	60	93
June ...	84	102	68	88	December	64	94	52	85

The rainy season is spread over four months in the year from about the 15th of June to about the 15th of October, the maximum rainfall being in the months of July and August. The average rainfall of Gujerat is about 33 inches; whereas at Mandwi it is about 50 inches. The following table shows the rainfall at Mandwi between 1925 and 1930:

Year:	1925	1926	1927	1928	1929	1930
Amount:	38·72	79·97	57·78	42·86	35·28	48·10

From the above table, and also considering the rainfall at Mandwi after 1863, I have been able to conclude that out of five years, there are two good years, the good year showing a rainfall above the average of the place.

To complete the study of the physical environment we shall investigate into the nature of the soils on which the people carry on their agricultural operations. The stretch of land in which the North-East portion of the Surat District, including the Mandwi Taluka is situated, belongs to what is known as the Deccan Trap. The surface and soil is rocky, rugged and often uncultivable, though in hollows and near river banks and streams we find portions of rich alluvial soil. The trap rocks contain the biggest proportion of ferrors of oxide, lime and soda. With the process of time oxygen and carbonic acid in the air react on these rocks, thus breaking them, and preparing the surface soil, aided by the changes in temperature and the action of water. To this is also added the soil formed by the decay of vegetation.

Three types of soil are found in the Surat District:

(i) Black alluvial soil, mainly suitable for cultivating kharif crops is found in the Chorasi, Bardoli, Chikhli, and some parts of the Mandwi Talukas.

(ii) Brown or red 'dadri' soil is mainly found in Pardi and the north-east portion of the Mandwi Talukas, best suited for the rabi crops.

(iii) Olpad and the western portion of the Chorasi Taluka mainly possess peat or white 'gori' soil, usually known as cotton soil.

In Mandwi Taluka, black soil is found in the villages lying on the banks of the Tapti, whilst as we proceed further inland we meet with red and brown soil, where lie most of the villages, populated by the aborigines. However, even in these villages, portions of the black soil are found in hollows, and between hte hills, where water gethers in the monsoon, the hollows thus becoming natural rice-beds or 'talavris.' The very high percentage of loss by ignition of the dried soil is a very characteristic feature of black soils, due to the pressure of much combined water and a small quantity of organic matter. The black soils are found to be deficient in humus-nitrogen, phosphoric acid, and organic matter.

The brown soil, which is sometimes almost red in colour, is mainly found on high surfaces and hilly regions, where rainfall is not very heavy. The soil is excellent for the cultivation of rabi crops which do not require much moisture, and the porous nature of the soil enables the roots to penetrate deep into the sub-soil. This soil is, however, uncultivable if the main soil is not deep enough, or if the sub-soil is 'kankri' or gravel.

The sub-soil of the brown soil is usually found to be of gravel in the Mandwi Taluka, especially in the forest villages, and hence the low productivity of the rabi crops. Morum is found to be the sub-soil mainly of the black soils and sometimes of the brown soils also. It is usually found about a foot below the surface, to a depth of 2 to 4 feet, where it merges with gravel. The morum sub-soil is of a porous nature, containing much half decayed rock, which is penetrable by roots and is thus most useful for the rabi crops, which form a large proportion of the produce of aboriginal farmers.

A general idea regarding the soils of the Mandwi Taluka will be obtained from the table given at the foot of the opposite page. *

Man needs water as much as land to live upon, for the primary satisfaction of his wants; and the presence of expanses of water play an important part in the life of human groups. The water-supply of the aborigines mainly depends upon rain water collected in holes dug in the earth near their houses which dry out during the hot months of April and May; and upon pukka wells and tanks some of which are said to have been built by the early wandering tribes of the Wanjaras who carried the produce of the villages to important cities before the railways were constructed; and others by the Local Boards.

* Cole: Revision Survey Settlement Report of Mandwi, 1904.

Rivers are important for the purposes of transport. The Tapti is the only river in the Surat District which is navigable to a distance of about 40 miles inland from Hazira in Chorasi Taluka to Bodhan in Mandwi Taluka. Rafts made of bamboos ply close to the banks carrying bags of grain, and other produce of the valleys to Surat. The Tapti flows by the South of Mandwi, and several small streams flow through the Taluka to join the river. These tributaries are of little importance, as before the close of the hot season they all more or less stagnate or dry up completely. The streams carry into the river the vegetation of the forests, thus fouling the waters which are locally called 'palu.'

We have so far investigated into the physical environment in which the people carry on their economic activities at the present day; but in order to understand these better it is necessary to investigate into their economic activities as they were carrried on in the past. The tribe of the Chodhras appears to belong to the Bhil community which is an important section of the Kolarian group of tribes to which also belong the Hos, Mundas, Meenas, Oraons and other tribes. These tribes occupied in the past and inhabit at the present day the belt of land from the Western coast and Kathiawad, through Central India to Bengal and Assam. Many of these are hill tribes with their homes in the Vindhya and Satpura Ranges and the northern portion of the Western Ghauts. They appear to have throughout lived on the barren and stony slopes of the hills and in forests round about them. Driven further and further inland by the Aryans, the Rajputs and the Mohammedans, they occupy to-day un-inhabitable and unhealthy areas away from the civilising influence of towns and means of transport. The Chodhras claim to have been once the residents of Powaghad Hill, at least they are certain that they were driven to the South by the Rajputs. They finally occupied territories near the present town of

Classification of soil as per Goverment survey.	Colour of the soil.	Nature of the soil.	Total number of villages.	Total area of Government occupied land in acres.
First Class ...	Light black	Peat and black alluvial cotton soil.	21	20,453
Second Class ...	Black	Dry and wet rice crop land, with morum as the usual sub-soil.	41	34,298
Third Class ...	Black and brown	Good rabi-crop land and poor black soil.	39	28,661
Fourth Class ...	Brown and red	Dadri soil, with gravel as the usual soil.	52	7,097

Mandwi where they were ruled by a Bhil Chieftain who held his court at Pipalwada Village. In the beginning of the seventeenth century the chief was deprived of his kingdom through the treachery of a Rajput. The kingdom finally fell into British hands when the line of Rajput Princes became extinct at the end of the nineteenth century.

We have no available history of the economic activities of the people in the very early tribal days. Perhaps they lived on 'gathering' when they collected wild fruits from the forests for their food, supplementing their supplies by hunting. Even to-day the Chodhras consume about twenty varieties of wild fruits which they collect from the wild plants and creepers in the forests. The history of their hunting days is also unrecorded but till very late they lived on the meat of wild boars, rabbits, wild goats, deer, etc. They used the spear, the bow and the arrow as the Bhils of the Dangs use at the present day, and lived on hunting within the tribal territory.

We have no information as to when the aborigines began cultivation, what crops they cultivated, what methods of cultivation they adopted and what implements they used in the early agricultural days; but it is likely that cultivation must have begun when the villagers came to settle down more or less in a definite territory. In the early tribal days till the annexation of the State of Mandwi with the British territories, the aborigines cultivated the crops, following the system of shifting cultivation, a system common to them all over India. A patch of forest land was cleared by the cultivators, and grass, weeds and wild plants were collected and burnt on the spot, thus preparing the seed-beds. Grains of the previous year were scattered after the first showers of rain, and the aboriginal was satisfied with harvesting a crop of coarse cereal, usually Kodra (Paspalum serobiculatum) or nagli (Eleusine coracana).

The tillage of the people was slovenly, and if the people were able to harvest any crop at all, it was because land was available in abundance for cultivation and the soil was virgin. The seeds were sown in the beginning of the monsoon and the cultivators never returned to the fields till after several months when the time for harvesting drew near. The families did not occupy any definite piece of land, but moved about from village to village cultivating their crops on any available piece of land within the tribal area. The aborigines maintain that till about 1870 they selected sites for cultivation by mutual agreement, and all differences were finally settled by their 'karbhari'. Tools for weeding and clearing the fields were unknown and the other implements used, including the plough, were made from indigenous materials. They were crude, inefficient, and unwieldy and did not give useful service or any long period of time.

During the rule of the Rajput Princes, the methods of cultivation of the aborigines did not improve, for the Rajputs were not agriculturists and with few exceptions, were slovenly and careless cultivators. They usually lived upon the produce of the Bhoomias, passing their time in hunting or fighting, or earning their living as Brahmins and traders. However, with the growth of towns, the aborigines began to grow many varieties of crops, especially Jowar (sorghum vulgare) and Kapas (Gossypium indicum). They brought the seeds of these crops, and learnt the methods of cultivating them from the Kunbis and Kolis who lived near the coast away from the hills, tilling more fertile soils. At the present day the cultivation of the aborigines is of the primitive type, they use primitive implements and seek to produce the maximum amount of crop with minimum effort.

The Rajput kings did not occupy the villages; but allowed the aborigines to continue their agricultural occupation on condition that they recognised the sovereignty of the Princes, and paid a nominal quit-rent as a token of their loyalty to them.* The conquerors mainly settled in the town of Mandwi, lying on the banks of the River Tapti, from where river trade could be carried on with Bodhan, and from Bodhan to Surat. The town came to be populated by the members of the court and government officials and their families, Banyas or traders and money-lenders, and the Jain priests whose rich temples with silver doors yet grace the historical town. With the increasing importance of the town, artisans from different places migrated to it, and the weavers of Mandwi made its name famous by the high quality of cloth they were able to produce. Even to-day the 'wankars' of the place continue their ancestral occupation, facing the heavy odds against Lancashire and Japan. Amongst the other artisans who even to-day serve the aborigines were the goldsmiths, silver-smiths, black-smiths, copper-smiths, potters, tanners, tailors, barbers and carpenters.

We have no historical records to show that the aborigines used any kind of currency till the Rajputs occupied Mandwi, for they carried on trade by barter with the nomadic tribe of the wanjaras. Money economy definitely began in the days of the Rajput Princes, though

* There were five systems of revenue collection in Rajwara:

(1) Buttaie: The State claimed ½, ⅓ or 2/5 share of the crop.

(2) Koont or Kunkoot: Which was a conjectural estimate of the standing crop on a measured surface made by the officers of the State in conjunction with the cultivator, the share of the State being converted into cash at the current prices.

(3) A tax in money, according to admeasurement of the fields, assessed previous to cultivation.

(4) A mixed tax in money and kind.

(5) Payment of a nominal Quit-rent. Tod: *Rajasthan*, Vol. I, pp. 514, 519-520; Vol. II, p. 1399.

even then trade by barter continued, and to some extent continues till this day.

A radical change in the economic life of the people may be said to have taken place with the recognition of private ownership of land by the British Government.

In the tribal days land belonged to no person. The peasant tilled a plot of land within the tribal territory by right of original settlement, and by right of first clearance of forest land. This latter right of ownership of land has been recognised by sages and Baden-Powell quoting Tod says that they " declare a field to belong to him who cut away the wood, or who cleared and tilled it, and a deer to him who owned the arrow which first struck it."* A special claim to land arises by virtue of the labour and skill expended on making it useful or profitable and later on the right arises from conquest or superior might. The title by 'first clearing' is overborne by the title by conquest notwithstanding that the claim by first clearing will probably be acknowledged by the conquerors as among themselves. This claim by conquest and superiority the next generation will euphemise as the claim by 'inheritance.'†

The Rajput Princes recognised the right of first clearance of the aborigines, but claimed a quit-rent in regard of the theoretical protection given to the ryot by the King. The Princes never appropriated to themselves the title of chief land-owner of all lands.‡

The British Government revolutionised the existing rights of ownership in land by introducing the system of Survey Settlement of lands. (1872). The functions of the Settlement and Revenue officers constituted a judicial agency, and " the jurisdiction exercised by them was at first established by the British Government not in its character of

* Tod, Laws quoted by Baden Powell: Indian Village Communities, Page 206; Cf. Pages 149, 401; Manu quoted on Page 511; Tod recognises the aborigines as the first proprietors of land. Tod: *Rajasthan*, Vol. I, Page 16; Cf. Page 308. In Rajwara the first settler was called the 'Bhomia.' " The Bhomia may at pleasure drive his own plough, right to the soil. His bhom is exempt from Juresh (measuring rod); it is never assessed and his only sign of allegiance is a quit-rent, in most cases triennial." Tod : *Rajasthan*, Vol. I, Page 514. Amongst the Mundas, " each village was occupied by the descendants of the family by whom the land was originally cleared; and the rights in it were unquestioned." Roy : Mundas, Page ii.

† Baden Powell: *Indian Village Communities*, Page 402.

‡ In Rajputana the principle was "Bhog ra dhanni Raj ho: bhom ra dhanni ma cho"; " the Government is owner of the rent, but I am the master of the land." Tod: *Rajasthan*, Vol. I, Page 512. In Mewar the Ryot compares his right therein to the akhya dhooba which no vicissitudes can destroy. He calls the land his bapota, the most emphatic, the most ancient, the most cherished, and the most significant phrase his language commands for patrimonial inheritance." Tod: Rajasthan, Vol. I, Page 511.

sovereign, but in its capacity of supreme land-owner."* Whatever the claim of the State to the land may have been, "it was not one of defined principles, nor of declaration of Imperial decree, but of tacit assumption."† It is only in Bombay "that the holder of land is, by express legislative enactment, called 'occupant', and in Burma and Assam which are Raiyatwari provinces in principle, though not formally so designated, he is called 'land-holder."‡

By the system of survey settlement the state appropriated to itself the right of allotment of land, and making a gift of the land to any institution or person. It also recognised the right of the Ryot to occupy land by the following claims :—

(1) By right of inheritance, (2) by private gift, (3) by right of purchase, (4) by right of a mortgagor. The State refused to recognise the right of original settlement and the right of ownership of land by right of first clearing, and thus deprived the ryot of one of the fundamental rights which was recognised by the Rajput Princes.

At the present day the State has the right to confiscate land property for default of payment of land revenue, to attach cattle and implements and sell them, to enact special laws or ordinances without the consent of legislatures empowering the officials of the State with special powers and enhancing the punishment for default of payment of land revenue to imprisonment and fine. The revenue official with the help of the police, has the right to enter any house of a land-owner by day or night, seize and sell away property and seal the house.

The State is the owner of all common lands, pastures and waste lands. The waste is used for grazing, and hay fields and hay-cutting is not known to the aborigines. The Chodhras maintain that when the system of shifting cultivation prevailed in the tribe, large areas of untilled forest lands were kept by common consent for the purpose of grazing. Perhaps the absence of any common or communal ownership of pastures was due to an abundant supply of unoccupied land when there was no pressure of population upon the soil.

Land came to assume the premier place in the economic life of the people as soon as it became property of the State, and important problems arose in its connection. The first of these is the problem of its distribution. Distribution of land in agriculture means two things:

(i) Division of land into farms owned by different individuals.

(ii) Division of land as between rent-receivers, cultivators who may be partly owners and partly tenants; and mere tenants.

The distribution of land is also to be examined from two different aspects:

* Henry Maine: *Village Communities in East and West,* Page 34.

† Baden Powell: *Indian Village Communities,* Page 426.

‡ Ibid., Page 428.

(i) Distribution of land by legal right.

(ii) Distribution of land for cultivation.

We shall first examine the distribution of land according to legal rights. Since the State is the sovereign owner of all lands, it naturally has the right to dispose off them according to the wish of the rulers. When a foreign Government appropriates the territory from another ruler, it is natural that those persons who help in bringing about this appropriation be adequately rewarded. Both the Rajputs and the British are not the original residents of Mandwi, and they had taken the help of many persons before the State could be annexed to their territories.

Inam lands were given to persons for either helping the Rajputs against foreign invaders and the aborigines, for rendering some special service to the British Government, or under treaty obligations with original rulers.*

The rights of an Inamdar are limited. He is not entitled to transfer the benefits conferred upon him to another person by sale, mortgage or gift. Though the land is given to him as a gift, a nominal revenue is exacted from him in order to maintain the sovereignty of the State over all lands. The State has the right to confiscate the Inam land. The lands given to the Patel and 'wethias' in return for their services, though included as 'inam' lands, are not such in the real sense of the term. The owner has only the right of use over this land during the term of his office.

"Any person who legally registers himself as an owner of land by purchase, transfer, inheritance, or any other form of legal apporpriation; and pledges himself liable to Government for the payment of land revenue is peasant proprietor or a tenant of the Crown".† Also any two or more persons may become joint-owners of land, jointly and collectively liable for the payment of land revenue by mutual agreement or consent.

Specific economic problems are best understood with statistical data. Rather than make a cursory investigation of a huge economic area, it is desirable to select a unit typical of the whole territory and make a thorough detailed investigation of the economic problems facing a typical economic group. Such a method has been successfully adopted by Dr. Mann and a number of other investigators of economic problems. I have therefore selected for investigation a typical village of the Mandwi Taluka, a village lying on the borders of the forest area, populated almost entirely by aborigines. The soil of the village is typical of

* In 1904, out of 24720 survey numbers in the Mandwi Taluka, 2785 were 'inams' or gift lands, and in 1930 the total area of the Inams in the Taluka was 6522 acres.

† *Cf.* Keatinge: *Rural Economy in Bombay Deccan*, p. 20.

those villages occupied by the aborigines, and in it we find represented almost all the problems which the aborigines have usually to encounter in their economic life. The village of Sathvav, with a population of 630 souls, lies on the Mandwi Jankhvav Road, four miles from the town of Mandwi. It is inhabited by 114 families, 112 of which are aboriginal.

In the year of inquiry the distribution of land in the village of Sathvav was as under :—

		Total area owned in acres.	Average size of holding in acres.
Number of Peasant-Proprietors ...	47	538·9	11·5
Number of absentee-Landlords ...	41	774·75	18·8
	88	1313·65	14·9

The precise nature of the distribution of land is shown below :

		Number of peasant-proprietors.	Number of absentee landlords.	Total.
Number of holders with more than	75 acres:	1	2	3
"	50 to 75:	0	2	2
"	40 to 50:	1	0	1
"	30 to 40:	1	5	6
"	25 to 30:	0	2	2
"	20 to 25:	3	3	6
"	15 to 20:	3	3	6
"	10 to 15:	8	5	13
"	5 to 10:	16	6	21
"	4 to 5:	4	3	7
"	3 to 4:	2	3	5
"	2 to 3:	7	4	11
"	1 to 2:	1	3	4
"	0 to 1:	0	0	1
	Total	47	41	88

The above figures do not include about 150 acres of land owned by 26 cultivators (9 of whom are not peasant-proprietors in Sathvav village) in the neighbouring villages of Andhatri, Badtal, Fulvadi, Gamtalao, Ghantoli, Kalamkuva, Makenjer, Serkui and Umarkhadi, which if considered will increase the average size of the holding of every peasant-proprietor by about 2 acres. From the above figures we arrive at the following conclusions :

(i) The land owned by the villagers is ·85 acres per head of population whilst the cultivable land available in the village per unit of population is 2·08 acres.* (ii) The average size of a holding of a

* Only 16 peasant-proprietors in the village live entirely on the produce of their own fields, the remaining peasant-proprietors are also tenants of other landlords or are labourers.

peasant-proprietor is about 13 acres. (iii) The majority of holdings in the village are between 5 and 10 acres.*

(iv) 9 out of 47 peasant-proprietors own more than 15 acres of land. (v) 14 out of 47 peasant-proprietors own less than 5 acres of land. (vi) The major portion of land is owned by absentee-landlords.

The chief cause of the small size of holdings in the village is absentee-landlordism. The following table shows the growth of absentee-landlordism in Sathvav village between 1906 and 1929.

Year.	Area occupied by agriculturist absentee landlords.†	Land owned by money-lenders as proprietors or mortgagors.	Total area owned by absentee landlords.	Percentage of the total cultivated area.
1906	122-30	185-39	308-29	23·5
1916	125-26	526—8	651-34	49·6
1929	143-31	630-33	774-30	59·02

The above table shows that the money-lenders have, during the last twenty years, acquired more than three times the area of land they had under their control in 1906. The transfer of land takes place in the following three ways:

(i) Land is relinquished by cultivators or sold by Government on account of the failure on the part of the holder to pay his rent to the State. (ii) Land is sold under the orders of the Civil Courts. (iii) Land is transferred by voluntary sale or by mortgage.

The consequence of the growth of the class of absentee-landlords is the loss of independence of the small farmer, a loss of his security which is as essential to him as he has no other valuable property, and a heavy fall in his income as he has to give away half his crop to the money-lender as rent. The small farmer has lost the little interest he

* The average size of a holding in Gujerat between 1886 and 1927 was as follows:—

1886—87	...	9·5 acres.
1900—01	...	9·2 acres.
1916—17	...	8·1 acres.
1921—22	...	7·7 acres.
1926—27	...	7·6 acres.

The following was the average size of holdings in the various Districts of Gujerat in 1921.

Ahmedabad	...	12·2
Kaira	...	4·9
Panch Mahals	...	8·3
Broach	...	12·6
Surat	...	6·3

† These are mostly aborigines residing in other villages.

had to produce the best crops he could; for the land is no longer his, and the fruits of his labours go to other persons.

The sudden leap in the figures of land owned by money-lenders in 1916 is caused by the "Chhapanio" or the great famine of 1900, when most of the aborigines had to borrow large amounts for their livelihood, mortgaging their lands for ten to twenty years.

The chief cause of the growth of absentee-landlordism is indebtedness. These two problems of rural economics, viz., absentee-landlordism and indebtedness are closely allied together, and it is not found possible to solve any one, without tackling the other. The peasant-proprietor, after the introduction of money economy, the production of commercial crops, and the increase in exports with growing facilities of trade and transport is always in need of capital, and capital cannot be obtained without security. The land-owner has no other security to offer but his land, and thus he has to risk the very source of his livelihood.

If indebtedness is the cause of absentee-landlordism, its quick growth is due to the prevailing civil court procedure. "A rigid and elaborate legal system too often has proved only an additional instrument of oppression in the hands of the more wealthy or better instructed litigants and an additional cause of ruin to the impoverished agriculturists."

The money-lender is the most intelligent and shrewd member of the rural community; the peasant is the most ignorant and the most credulous of all peoples. The money-lender reads the law, he knows how to make an infallible contract leaving no loophole of escape for his victim. The immediate need of the cultivator for money compels him to sign the mortgage deed, the contents of which he is hardly aware of. Litigation arises at the time of the expiry of the loan. The land-owner has to undergo heavy expenses of litigation, the civil suit drags on for months and finally ends in favour of the money-lender, for invariably the letter of the law is found to be against the cultivator. Thus the landlord becomes a tenant of the money-lender, a mere labourer on his own land.

The only important effort which was made by the Government to prevent the disastrous results of their policy was the enactment of the Land Alienation Act of 1900.

According to the provisions of the Land Alienation Act, the survey numbers in a village are classified as "old agreement lands" and "new agreement" lands. The "new agreement" lands are those, the owners of which desire to take advantage of the Land Alienation Act, whilst the "old agreement" lands are those which do not come under the provisions of the Act, as their owners did not desire the advantages offered to them for various reasons. This element of choice almost

negatived the value of the Act, for the money-lender had secured such a hold over his debtor and the cultivator was continually in need of cash capital, that he could not take advantage of the Act, even if he desired to do so. The total area of old agreement lands in the village of Sathvav in 1929 was 1043 acres, whilst the area of the new agreement lands was only 204 acres. The total area of cultivated old agreement land in the same year in Mandwi Taluka was 81,279 acres as against 14,463 acres of new agreement lands. The above figures denote the extent to which the peasants took advantage of the Act during a period of about thirty years.

The problem of the sub-division of holdings has to be discussed with regard to the distribution of legal holdings. The Chodhras have not yet adopted the Hindu Law of Inheritance and Succession and hence the evil of sub-division of holdings at the time of the death of a land-owner between his sons reducing the size of the holding, is not found to prevail amongst them. The patria potestas is yet supreme, and on his death, though the sons become joint heirs of the estate, they usually continue to till the lands together and share the produce or the income till a separation of the brothers becomes necessary in the interest of the peace and well-being of the families. However, in certain cases, especially where the size of the estate is large and the lust of self-aggrandisement is great, such a sub-division does take place to the detriment of the interest of the families. Two such instances of the sub-divisions of parental estates between the sons are available in the village of Sathvav.

The size of a holding is not truly measured by the legal rights held by a land-owner over a piece of land. Any piece of land owned, tenanted or cultivated by a farmer which contributes directly or indirectly some income or yield to the owner or cultivator, constitutes the holding of that person.

In order to determine the size of such holdings we shall consider the distribution of land for the purpose of cultivation between the cultivators residing in the village of Sathvav as given in the following table :—

	Number of cultivators.	Total cultivated area in acres.*
Land owned and cultivated by peasant proprietors	47	538
Land cultivated by tenants paying rent in cash or kind	69	712
Total land in the village of Sathvav cultivated by local villagers	87	1202
Total land cultivated by cultivators residing in the village, including in other villages ...	94	1528

* The figures are approximately correct. We are unable to obtain the exact figures on account of joint ownership and cultivation of plots.

In order to understand properly the economic problems facing the families, we have divided the families of the village of Sathvav into three economic groups. The first group consists generally of the important landlords of the village : to the second group belong the small peasant-proprietors and tenants, whilst the last group is composed of the poorest population of the village consisting of the labourers and menials. The first group consists of the important members of the village community, owning ten or more acres of land, cultivating about twenty acres, with an annual gross income of Rs. 500 or more. The second group of families consists of tenants cultivating more than 6 acres of land, sometimes owning land not less than one acre, and having an annual gross income of Rs. 150 or more. The last group consists of labourers, halis and farmers cultivating not more than 6 acres of land, not owning any land, and earning a gross annual income which is not more than Rs. 150.

The following shows the composition of families according to this classification in the village of Sathvav :—

Group I:	Families of Chodhra peasant-proprietors	8
	Family of a Parsi peasant-proprietor ...	1
	Total in the group I ...	9
Group II:	Families of Chodhra peasant-proprietors	27
	Families of Chodhra cultivators ...	14
	Total	41
Group III.	Families of Chodhra peasant-proprietors	17
	Families of Chodhra cultivators ...	27
	Family of a Parsi cultivator ...	1
	Families of Chodhra labourers ...	13
	Families of Vasava labourers ...	4
	Families of Dhed labourers (untouchables)	2
	Family of Parsis living on charity ...	1
		65

The average size of a cultivated holding comes to 16·25 acres of cultivated land and per head of population it is 2·35 acres.* The precise nature of the distribution of land according to cultivators in the three economic groups is given below :—

* The size of an average holding is sometimes estimated per pair of bullocks. According to such a calculation, the average size of a holding per pair of plough bullocks in the village of Sathvav would be 12·87 acres.

—	No. of families belonging to Economic groups. Groups.			Total No. of holdings.
	I.	II.	III.	
Number of cultivators with more than 75 acres	1	0	0	1
" 50 to 75	3	0	0	3
" 40 to 50	3	0	0	3
" 30 to 40	0	3	0	3
" 25 to 30	1	5	0	6
" 20 to 25	1	4	2	7
" 15 to 20	0	12	1	13
" 10 to 15	0	11	12	23
" 5 to 10	0	7	9	16
" 4 to 5	0	0	3	3
" 3 to 4	0	1	3	4
" 2 to 3	0	1	7	8
" 1 to 2	0	0	3	3
" 0 to 1	0	0	1	1
Total ...	9	44	41	94

	A.	G.
Therefore the average size of a cultivated holding of cultivators of Group I is	51	8
The average size of a cultivated holding of cultivators of Group II is	16	8
The average size of a cultivated holding of cultivators or Group III is	7	4

Opinions have differed between economists as to the size of an economic holding. An economic holding comprises the area of land necessary for the maintenance of a family which must be provided with the bare necessities and comforts of life. No rule can be laid down regarding the size of such a holding, for the size is likely to vary at different places and with different families paying consideration to the size of the family, the type and situation of land, the quality of the population and the methods employed for the cultivation of crops. The usual size of an economic holding in India has been estimated by many economists between 15 and 20 acres. We would consider 20 acres of land at Sathvav and the other aboriginal villages as a bare necessity for providing a family of 6 or 7 persons. To many it would appear that 20 acres of land is too much for a population living at such a low standard of life, having a small number of wants, and needing very few comforts. But in considering the size of the holding we have paid attention to the poor type of soil, the very low yield per acre, the primitive methods employed in cultivation by the cultivator, and the heavy burden of indebtedness and land-revenue upon the people.

We notice that in the village, only 16, *i.e.* 17·02 per cent of the total number of holdings are economic holdings, and that the majority of holdings of families belonging to the II and III Groups are not sufficient for their maintenance.

The economic situation created by the uneven distribution of holdings is further aggravated by the excessive fragmentation of holdings which prevails to a very great extent in the aboriginal villages. The aboriginal cultivator loses his lands on account of his indebtedness and thus deprived of half of his total produce, and also unable to find employment or buy or rent any available piece of land in the village, he tries to find land for cultivation even in the neighbouring villages. No less than 91 plots of land are cultivated by the residents of Sathvav in villages lying on the boundaries of the village. The following frequency table shows the number of fragments which compose the 94 cultivated holdings of the village.

Number of fragments.	Number of holdings with specified number of fragments.
Single plot holdings.	11
2-5	67
6-10	12
11-15	2
More than 15	2
357	94

Thus on an average there are about 3·8 fragments per every cultivated holding in the village. The size of these fragments or plots is given below :—

Size of Plots			
above 15 acres	...	...	4
10 — 15 „	...	...	18
5 — 10 „	...	...	95
4 — 5 „	...	...	29
3 — 4 „	...	...	55
2 — 3 „	...	...	101
1 — 2 „	...	...	41
Below 1 — „	...	...	14
		Total ...	357

There are only 11 single-plot holdings in the village, and most of these belong to poor cultivators who are not able to purchase or rent another, whilst in the majority of cases the plots lie scattered all over the village. The excessive fragmentation of holdings in the village makes it very difficult, if not impossible, for the cultivator to grow valuable crops and irrigate and manure his lands. Improvements on

lands are difficult to make when the cultivator has many fields to attend to. It may become possible for the cultivator to use better implements if his holding is a single field. The evils of fragmentation are, however, reduced if the plots are of Kyari soil, for small plots are better suited for the cultivation of the paddy crop. Fragmentation, furthermore, brings about an equalisation of opportunities, enabling the cultivators to sow many crops, and to provide varieties for their meals. Rotation of crops is also easier when the holding is composed of many plots, and there is a more proper distribution of rainfall in the fields when the plots cover a larger area of land.

In conclusion we must say that the evils of fragmentation far outweigh the benefits, and if absentee-landlordism continues unchecked, there is a danger of the holdings becoming so fragmented, that the process of fragmentation will seriously affect the quality and quantity of the produce, and the income of the farmers.

The most important form of the fixed capital of the farmer is land. The value of land depends upon important and variable factors which makes it difficult if not impossible for its owner to evaluate it at a particular time. The value of land depends upon certain permanent as also variable factors like the type of soil, its proximity to town and market, its nearness to railways or to other means of transport, facilities for water, and health conditions and climate of the place. The value of land rises with a rise in prices, the opening of new markets, and the skill and industry of a proprietor. Judging by the above standards, the value of land in the aboriginal villages is bound to be low, because (i) the soil is of a poor variety, (ii) the villages are away from towns and railways, (iii) facilities of transport are limited and costly, (iv) the water supply is poor, and there is practically no facility for lift irrigation, (v) the climate is bad, (vi) there are no improvements on land, (vii) there is hardly any demand for land in these areas.

It is possible to arrive at a general estimate of the present value of land per acre, and the total value of land in the village; but such an estimate should be taken as merely affording a general idea of this form of capital because sales and purchases of land at the present day are very rare, and the money lent on its security depends more upon the whims and caprices of the money-lender than upon sound economic factors.

We shall attempt to measure the value of land by considering the rate of rentals in the village; but here again, the estimate will not be very reliable and will be to some extent exaggerated as the rent is paid in kind and therefore the valuation will depend on prices. Moreover, the charge of Land Revenue is lighter in the aboriginal villages compared to the other Ujliparaj villages. The following estimate is obtained

after considering the value of rents according to the prices prevailing at Mandwi when they were charged:

Total acreage in tenancy		890 acres.
Gross total income	Rs.	4154– 0– 0
Gross income per acre	Rs.	4–10– 8
Less Land Revenue	Rs.	1– 6– 0
Net income per acre	Rs.	3– 4– 8
Value of land per acre at the rate of 4% ...	Rs.	82– 5– 0

As the soils of the village of Sathvav are not very productive, as the yield of jarayat and kyari land are not very different and as there is a heavy demand of land for cultivation, we estimate the value of an acre of land to be Rs. 35, after giving due consideration to the sales of land in the Taluka and the village after the year 1860, and the present low level of land values. At the above rate, the following will be the total land value of the village:

Value of land of peasant-proprietors	Rs. 18,830
Value of lands owned by money-lenders	Rs. 22,085
Value of lands owned by other absentee-landlords ...	Rs. 5,040
Total value of lands in the village	Rs. 45,955

PRICE OF LAND IN MANDVI TALUKA*

Year.	Total number of acres sold.	Value of land per acre.
		Rs. as. p.
1866	$3\frac{21}{40}$	123 11 0
1869	$18\frac{21}{40}$	44 9 5
1874	$446\frac{5}{40}$	2 10 10
As given in Revision Settlement Report of 1904 (Appendix K & L).	821-33g.	26 14 10
Do.	60-1g.	17 9 2

Rate of simple mortgages of land and mortgages with possession in Mandwi Taluka as given in the Revision Survey Settlement Report of 1904 :

*Campbell : Bombay Government Gazetteer, Vol. II, Page 273. Cole. Revision Survey Settlement of Mandvi Taluka, 1904, Appendix K and L.

Total number of acres mortgaged.	The sum for which land was mortgaged.	Average rate per acre.
A. G.	Rs.	Rs. As. Ps.
724 24	14,979	20 10 9
880 37	24,428	27 11 8

The following table shows the value of land of the various types of soil in the village of Sathvav between 1913–1930.

Survey Plot Number.	Type of soil.	Acres.	Sale value.	Price per acre.	Date of sale.
		A. G.	Rs.	Rs.	
110 2nd.	Talavri	1-21	91	60	8-10-1910
151	Talavri	5-35	800	136	1- 7-1926
193	Talavri	5-30	435	75	22- 9-1927
111 1st.	Talavri	5-12	250	47	16- 4-1930
108	Black	3-19	40	11½	8-10-1910
105 2nd.	Black	0-33	150	181	16- 7-1917
186 1st.	Black	2-13	300	129	23- 3-1926
135	Black	3-32	300	79	19- 4-1927
16 2nd.	Black	2- 2	300	146	13- 7-1927
Value per acre of Kyari land Rs. 94.					
211	Dadri	2-28	90	32	20- 6-1923
47 and 48.	Dadri	5- 6	600	116	8- 8-1923
26 1st, 27, 248	Dadri	21-19	799	37	17- 9-1923
247	Dadri	3-11	125	38	4- 2-1929
175 2nd.	Dadri	1- 9	61¼	50	11- 4-1929
254	Dadri	10-39	300	27	21- 5-1930
Value per acre of Jarayat land Rs. 50.					
Value per acre of land in the village Rs. 72.*					

We notice that 48% of the total land capital of the village is controlled by money-lenders, and only 41% is left to the landlords of the village. The chief use of land to a peasant-proprietor is the loan he is able to obtain on the security of his land, and with the growth of absentee-landlordism he is threatened with the loss of his most valuable asset, thus depriving him of the only source of securing a loan.

Having seen the various characteristics of land possession in the village, and the type and size of holdings and the problems arising from them, we shall proceed to investigate the problem of tenancy in the village.

Any person who rents a piece of land after an oral or written agreement or contract with a peasant-proprietor or absentee-landlord becomes his tenant and is liable for the payment of rent in money or

* In most cases the value per acre of land owned by a money-lender is high as usually he tries to get into his clutches landlords who own the best type of land in the village.

share of produce to the land-owner for a period of time agreed upon in the contract. The tenant is not responsible for the payment of land revenue or any other liability of the land-owner. In some cases a piece of land is leased to a number of tenants who are jointly liable for the payment of rent to the landlord. In some other cases the tenant agrees merely to pay the land revenue to the Government on behalf of the land-owner, so that the landlord derives no income from his land, but escapes the liability which otherwise he would not be able to meet, thus losing his land.

The rental that a tenant has to pay for a piece of land is fixed usually by an oral agreement, and this rent is called 'ganot'.

It is usually the custom to lease the land to the cultivator who occupies it, and in all cases where the money-lender becomes the proprietor, his former debtor becomes his tenant.

The rights of a tenant are fixed by custom and convention. He cannot be ejected by the land-owner during the agricultural year which begins about the middle of May and ends at the time of the Holi festival. The tenant is in no way held responsible for any harm or damage done to the estate by accidents or other causes over which he has no control. He has to make his own arrangements for the protection of crops and fields, fence them, prepare the galleries, dig water-holes wherever necessary and live in his own house. All improvements in the land must be made by the tenant, and in theory they belong to him, but if the improvements are immoveable assets, then they belong to the land-owner.

The following table shows the total area leased by the cultivators, the amount of rent paid in cash and kind, and the rent per acre in the villages.*

	Total area rented in acres.‡	Total rent paid in the village.‡	Rent per acre of land.
Tenants paying rent in cash in the village ...	259	Rs. 1,104	Rs. 3-3-5
In other villages ...	85		
Tenants giving half the produce as rent in the village ...	453	Rs. 3,050†	Rs. 5-9-5
In other villages ...	93		
	890	Rs. 4,154	Rs. 4-10-3

* The figures include lands rented in other villages, by the cultivators residing at Sathvav.

† The figures are approximately correct.

‡ Where it was not possible to obtain the amount of crop given as rent for 1928-29; the figures of 1930-31 were adopted at 1928-29 prices. Where both are not available, the rent was estimated at the average rent per acre.

Thus the majority of cultivators pay the rent in kind.* The amount of rent paid under the system is effected by two factors viz., (1) the kind of crops harvested and (2) the price of grain in the market. The rent received by the land-owner is not fixed, and depends upon the success or failure of the season, and the kind of crops cultivated by the tenant. When prices are high the land-owner is benefited, when they are low the cultivator is benefited.

The tenant usually prefers to pay the rent in kind for the following reasons :—

(i) The payment of rent in cash involves risk, as the same amount is to be paid even when the harvest is bad. (ii) The cultivator is always in want of cash, so that he has to borrow from the money-lender whenever he is in need. (iii) The tenant can dispose off bad grain when he has to pay the rent in kind. (iv) As the land-owner is never able to measure the exact amount of produce, he is always given a lesser share under various pretexts. (v) Rent is usually paid to the absentee-landlord who is usually the money-lender, together with the interest on debt; and therefore the cultivator is always able to plead that he has nothing left for home consumption, and thus gets the amount to be surrendered to the Bania considerably reduced.

Payment of rent in cash is preferable when the soil is black-Kyari or which yields commercial crops fetching better value in the market. This will not be the case when prices are low. When rent is paid in cash, the cultivator escapes the dishonest means employed by the money-lender to secure the most for himself by using false measures, or claiming the best produce of crops for himself and taking advantage of the ignorance of the cultivator. Payment of rent in cash is preferable as in most cases the amount paid per acre in cash comes actually to less than the amount paid in kind.

Next to land, the most important economic asset to the cultivator is cattle. The cattle are treated as members of the household. Bullocks and sometimes he-buffaloes are useful as draughts for the plough or as the driving pair for a cart. Cows and buffaloes are useful for the dairy produce which adds to the food-supply of the family, and for supplying more draught cattle to the cultivator. Goats

* The origin of the payment of rent in kind may be traced to the days of the Rajput Princes, when Banias began to lend money to the aboriginal cultivators. To maintain the interest during abeyance, it was generally stipulated that a certain portion of the harvest shall be reserved for the mortgagee—a fourth, a fifth, or 'goojri',—a share so small as to be valued only as a mark of proprietary recognition.

Cf. Tod: *Rajasthan*, Vol. I, p. 517.

are useful for their milk and they also serve as sacrifices to the spirits and gods, together with fowls. The latter add to the income of the family by the sale of eggs and chicken.

Cattle of the 'Kankrej' breed, locally known as 'madhaya' are used by the villagers; but in the majority of cases the cultivators use local breeds, the bulls and other calves being reared in the village itself. Only some cultivators who are well off use cattle of the Talabda breed.

The breed of cattle is very poor and no attempts are made at scientific breeding. Cows are left to pasture with the bulls and the breed produced is poor in strength and stature. In some villages a 'sandh' or bull-king is kept which is allowed to pasture freely and is given special food; but the practice is now discontinued in the aboriginal villages as a bull was responsible for destroying the crops in the fields which led to serious feuds within the village community.

The bad breed and poor quality of cattle is mainly due to want of proper nutrition. All cattle except bullocks used as draughts are sent to the pastures for eight months in the year, and rarely any more food is given to them. The food of the bullocks consists of hay, 'gotar', 'kadab' and 'khol' or pulverised grains. Sweet oil is given once a week. Bullocks are given a special feed twice a month consisting of salt, jaggery, nagli flour, pulverised grains, and oil cakes. Some rich khatedars add 'ghee' to this bumper meal. Paddy being the main cereal crop of the village, and as Government pastures are insufficient, the cattle are fed with straw which is less nutritive and reduces their vitality. In the monsoon green grass is given if the stock of hay is exhausted, and this is not easily digested.

We notice the following reasons to explain the deterioration of the cattle in the village:

(i) Insufficient and unnutritive food, absence of good fodder and inability of the farmers to stall-feed the cattle. (ii) Want of sufficient pastures and the inability of farmers to grow lucerne, guinea grass or any other kind of fodder crops. (iii) Prevalence of cattle diseases, and absence of proper remedial treatment. (iv) Absence of proper care of the calves by the owners. (v) Absence of scientific breeding. (vi) The carelessness of the young herdsmen when they attend to the cattle in the pastures. (vii) The general ignorance of the people. The poor breed and deteriorated condition of the cattle are responsible for the low income yielded by them.

The following table indicates the number of cattle, other animals and fowls found in the village at different dates and their distribution in the village in 1930:

Kind of cattle.	1919–1920	1924–1925	1929–1930	Personal investigation 1930.	Increase or decrease over 1919–1920.	Number of animals per family.
Bullocks ...	208	267	252	237	+29	2·07
He-buffaloes ...	...	2	2	3	+ 3	·03
Bulls ...	...	...	10	11	+11	·9
Total working animals.	208	269	264	251	+43	
Cows ...	105	145	131	146	+41	1·3
She-buffaloes ...	24	12	14	14	—10	·1
Calves ...	152	157	217	194	+42	1·7
Buffalo-calves...	18	7	16	5	—13	·04
Total milch cattle and young ones.	299	321	378	359	+60	
Total number of bovine cattle	507	590	642	610	+103	5·3
Goats ...	180	51	158	192	+ 12	
Other animals...	...	...	...	1	+ 1	
Fowls ...	...	...	...	170	...	

Thus we notice that there is a slight increase in the number of cattle and other animals of the village since 1919 ; though there is a fall in the total number of working animals during the last five years. The decrease during the last few years is due to the almost annual epidemics which spring up in the village, causing the death of many cattle.

The average number of bullocks in the village owned by the cultivators is 2·07, and thus on an average every family owns a pair of working animals. Out of 96 cultivating families in the village, 29 families own two or more than two pairs of bullocks, whilst 11 families own less than one pair. Therefore about 60% of the families in the village have the minimum bullock power, and allowing for the fact that working animals are not needed by the family of labourers, we conclude that the available bullock power is barely sufficient for the village considering the small size of holdings.

It is not possible for us to judge the bare needs of the farmers for milch animals: but there must be at least one cow or she-buffalo in milk all the year round to supply the family with the necessary farm produce. In December 1929, only 30 cows out of 146 were in milk

in the village. Only 63 families out of 114 own milch animals, and 9 families own buffaloes. The majority of families are supplied with milk hardly three months in the year. Thus the supply of milch cattle in the village is very poor.

Goats are useful animals, and in an aboriginal family they are most valuable for yielding a fair amount of surplus income. The cost of their food is practically nil, they are able to shelter themselves under a tree, and if they are lost, the value of the loss is comparatively small for the owner. They supply meat to the non-vegetarian population, and their milk is useful for the children of the family. In the aboriginal villages at the present day, goats are not kept by the upper classes of the population as a stigma is attached to them, and therefore we find that only 29 families, mostly labourers and Parsis own goats in the village.

Fowls are kept only by the labourers and 32 families secure a surplus income from the sale of eggs and chicken.

The price of cattle depends upon their size of body, build, breed, capacity to work or to yield income or calves to supply the future stock of cattle. The price of a bullock varies between Rs. 150 and Rs. 40, the usual price being Rs. 60 to Rs. 75. The price of a cow is between Rs. 25 and Rs. 12; of a she-buffalo between Rs. 150 and Rs. 30, the usual price being Rs. 55 to 70; of a goat between Rs. 7 and Rs. 2 and cocks fetch Ans. 8., hens Ans. 4 and chicken Ans. 2. The price of fowls vary according to supply and demand.

The total capital value of the animals in the village is as follows:—

			Rs.		Rs.
				per animal	
Bullocks	237	@	50	" "	11,850
He-buffaloes	3	@	60	" "	180
Bulls	11	@	15	" "	165
Cows	146	@	16	" "	2,356
She-buffaloes	14	@	55	" "	770
Calves	199	@	10	" "	1,990
Goats	192	@	4	" "	768
Fowls	170	@	¼	" "	42½
Horse	1	@	100	" "	100
					Rs. 17,521½

Next to land and cattle, the indispensable asset of the cultivator is his implements. The implements of the villagers may be best described as primitive. The plough looks like a half open pen-knife which is barely able to scratch the soil. The sickle is more a toy than an implement. Some of the implements are improvised from the branches of trees whilst the cultivator does not know how to use the more elaborate ones obtained at the weekly 'hath' at Mandwi.

The most important implement of the agriculturist is the plough. Its efficiency depends upon its capacity to turn the dormant sub-soil, its proper weight, and its easy manœuvring. The hard soils of the village need a heavy plough. The cultivators, when they find the plough too light for the soil, turn it upside down and tie heavy stones in the middle of the 'hal', but their genius for improvision serves little purpose.

The plough of the cultivators is made of tanas wood. At the extreme end of the 'hal' is the 'chavru' and 'pati' or knife, mostly of iron and sometimes of wood. Good bullocks and heavy ploughs result in efficient tilling, but bad bullocks and heavy ploughs only succeed in scratching the soil. The plough in the village is light, and the breed of bullocks is poor.

Till lately the use of the hoe or 'kulpi' was unknown to the villagers. In dry lands the conservation of soil is done by means of a fine mulch done by interculturing the crops repeatedly with a curved-blade-harrow during the intervals between showers of rain, thus removing the weeds and protecting the roots of the crops. The 'kulpi' is a lately introduced implement, in size a little smaller than the plough, but not behind it in its want of efficiency.

Next to the plough, the cart is the most useful article to the cultivator. The cultivator rarely lives upon the land he cultivates and therefore a cart becomes essential for removing the crops from the fields and taking manure, implements, etc. to the site of cultivation. The bullock-cart is usually made of tanas, dhamora and sag timber and is drawn by two or four bullocks or he-buffaloes. The cart is found in the houses of important cultivators who lend its services to their neighbours. Not only is the cart an expensive article for the poorer cultivators to purchase; but its recurring expenses are also heavy. The cart is a source of income, and under this head the total income of the village in the year of investigation was Rs. 189 or Rs. 7 per cart.

The following is a complete list of the implements used in the village:

	Life in years.	Cost.	Articles from which implements are manufactured.	Use.	Repairing charges per annum
		Rs. as. ps.			Rs. as. ps.
Hal (plough with a yoke).	3	5 0 0 7 0 0	Tanas wood with iron bit.	Ploughing ...	1 0 0
Kulpi (Harrow)	3	3 0 0	Babul and cast iron.	Interculturing and levelling the ground.	0 8 0
Orni (Seed-drill)	5	1 8 0	Bamboo ...	Bamboo ...	...

	Life in years.	Cost.	Articles from which implements are manufactured	Use.	Repairing charges per annum
		Rs. As. Ps.			Rs. As. Ps.
Kuhādi (axe with vertical edge).	10	1 4 0	Bamboo and cast iron.	Chopping wood, branches etc.	
Kōdāli (Pick-axe).	5	0 6 0	Do.	Digging the ground ...	0 4 0
Chānchvō (axe with horizontal edge).	5	1 8 0	Do	Chopping wood ...	
Pāvdō (hoe)	5	1 4 0	Wood and iron (foreign make)	Ordinary hoeing.	
Panjēthi (fork)	2	1 8 0	Iron ...	Gathering leaves, or pulling thorns, manure from the pit, etc.	
Parāi (Drill)	15	1 8 0	Iron ...	Deep digging	
Dātardā (sickle)	3	0 4 0	Iron with wooden handle.	Reaping crops	
Dātardi (sickle with serrated edge).	3	0 4 0	Iron with wooden handle.	Reaping crops	0 6 0
Dhāriu (scythe)	3	0 12 0	Iron with long wooden handle.	Cutting branches etc.	
Grinding stone	15	5 0 0	Stone ...	Grinding ...	0 4 0
Kōsh (leather bag).	5	15 0 0	Leather ...	For drawing water.	1 0 0
Jusri ...	2	0 2 0	Leather ...	Tying bullocks to the yoke.	0 3 0
Supru (winnowing fan).	1	0 3 0	Date palm leaves.	Winnowing ...	...
Gāli (cart) ...	10	90 0 0	Tanas and sag timber.	Carrying manure, grass.	10 0 0
Savāri ...	10	150 0 0	Do.	Carrying per- n.	12 0 0

Most of the implements are made by the blacksmiths at Mandwi, and they cost less than in other parts of the District, their efficiency and duration of life being complementary to their cheapness. The blacksmith could manufacture better implements if the cultivators were able and willing to bear the cost.

Successful cultivation depends very largely on the efficiency and extent of supply of implements. A census of implements taken in the village is given below together with their capital value. We have omitted very small implements of little value.

			Rs.As.Ps.		Rs.As.Ps.
Savari (Riding cart)	1	@	150—0—0	...	150—0—0
Carts	27	@	90—0—0	...	2430—0—0
Ploughs with yoke	121	@	7—0—0	...	847—0—0
Harrows	62	@	3—0—0	...	186—0—0
Axes (Kuhādi)	150	@	1—4—0	...	187—8—0
Axes (Chānchvō)	42	@	1—8—0	...	63—0—0
Pick-axes	149	@	0—6—0	...	55–14—0
Hoes	16	@	1—4-0	...	20—0—0
Drill (Parāi)	22	@	1—8—0	...	33—0—0
Panjēthi	39	@	0—8—0	...	19—8—0
Scythes	52	@	0–12—0	...	39—0—0
Sickles	596	@	0—4—0	...	149—0—0
Seed-drills	73	@	1—8—0	...	109—8—0
Kōsh	1	@	15—0—0	...	15—0—0
Grinding stones	116	@	5—0—0	...	580—0—0
Total capital value of implements in village				...	4,884—6—0

Of these the most important instruments according to the prevailing notion of the people are carts, ploughs and seed-drills for the average cultivator, whilst the most important implement is the *Dākhlō* or sickle which the child carries at the age of seven, and which accompanies the cultivator to the funeral pyre.

The following table shows how some of the important implements were owned per head of the total number of cultivators in the village in the year of our inquiry:

	Total		Number per cultivator
Carts ...	27	...	0·27
Ploughs ...	121	...	1·2
Harrows ...	62	...	0·64

We notice, therefore, that the implements are insufficient for the cultivators, and this insufficiency is usually met with by hiring and exchanging implements in time of necessity.

Human beings, with the gifts of nature and other capital at their command, are not able to earn their livelihood without the assistance of their fellowmen. In the present capitalistic system of society, where land could be only possessed by those who have the means, the employment of labour becomes necessary to exploit fully the resources at the disposal of the individual.

In the villages of Mandvi there are two types of agricultural labourers, as in the rest of Gujerat. (1) The halis or permanent servants attached to a family for life, or for a period of one year.* (2) Labourers who work on daily wages.

The 'halis' are serfs or hereditary servants or bondsmen attached to families of the well-to-do aboriginal peasant-proprietors or the Ujliparaj land-owners. According to the *Bombay Gazetteer* the term 'hāli', literally a ploughman, was "confined to families, who, for generations, have held the position of hereditary servants." "This may have been true in the past, but to-day in Mandvi the term is used for any farm servant attached to a family for a period of at least one year. The daily wage-earner is called "Komāryō" or "Komārwālō". The 'hali' usually calls his master "dhanyāmō" or one who gives wealth. Originally this term meant the owner of a person who is indebted to him, but who is not able to pay back his creditor, and is therefore obliged to give his services in payment for debt, services not only for a life-time, but services of his wife and children after his death. It is in this manner that in the past the 'hāli' became a permanent servant of the household.†

The hali in Mandvi is a permanent servant employed by a family for a period of one year, getting three months' leave, and receiving fixed wage, boarding, lodging, and clothes. The contract is renewable every year. Amongst the aborigines the hali is often an orphan boy or girl, or an unmarried son or daughter of a poor labourer. If the hali has no home, he stays with his master, otherwise he goes home to his family for a period of three months after the Holi festival. If he stays with his master during this three months' holiday he does not receive any extra wage and is obliged to do jobs entrusted to him.

The hali is given Rs. 10 for nine months' work in the year, that is about half anna per day with free boarding, lodging and clothes. When unmarried 'halis' are married, the expenses for the marriage are incurred by their masters, and the bride-price is usually paid by them. The halis receive a gift of four annas on all important festivals, and they do not contribute to the expenses of tribal festivals and ceremonies.

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* The hali or "bussee" of the Rajput "approximates closely to the 'tributarii the coloni, perhaps to the servi, of the Galic Franks, who were cultivators of the earth, and subject to residence upon their master's estate, though not destitute of property or civil rights'—precisely the condition of the cultivator who now tills for a tax-master the fields he formerly owned, degraded to the name of hallee a ploughman."—Tod: *Rajasthan*, Vol. I, p. 187.

† The custom of sons working for the payment of debts of fathers was prevalent amongst the Todas. This was called "Kulvatkerthchi" or "Kulvartkerthiti" —Rivers: *Todas*, p. 566.

A 'khatedar' who desires to employ a hali usually obtains one from amongst the poorest labourers of the village, and he usually selects a young man or woman. Halis usually leave their service when they marry, as the masters are not willing to employ both the husband and the wife.

In aboriginal villages, the number of persons who live actually on labour is usually small and in the majority of cases we find that small peasant-proprietors and tenants also work as labourers in the fields of absentee-landlords and the bigger peasant-proprietors. Even children earn a few rupees by performing small jobs and working as herdsmen. The following table shows the conditions of labour supply in the village of Sathvav:

Total population.		Full time labourers.		Part time labourers.		Child wage earners.
Males	Females	Males	Females	Males	Females	
308	322	36	29	50	40	15

The employment of labour during the seasons is by 'hōlās' or batches of sixteen men. Usually half 'hōla' or eight men are found necessary on an estate of two or three acres of dadri or one acre of Kyari soil. The hōla is given 2 mds. of grains as wages or a wage of Rs. 2 plus an afternoon meal to each labourer.

When individual labourers are hired, they are only employed for one day on oral agreement. In some cases families of labourers are attached to certain landlords, and they are given a preference over others. The offer for work comes about a day previous to when labour is required, and the acceptance of the offer is usually immediate. The wages are always understood, and the terms of the agreement are implied and not explicit. Agreements are almost universally honoured and payments are made on the daily-wage system. The wages of a labourer are usually paid daily, or at the latest within three days. In rare cases wages are given for piece work. Some landowners who usually cultivate the fields with their own labour with the help of the members of the family, hire komarias at the time of sowing or thrashing on the understanding that they will complete the amount of work allotted to them.

In most cases, the wage is paid in kind, but the labourer may demand cash if he so desires. This system is not always to the benefit of the labourer as he is usually given the cheapest variety and the poorest quality of grain, and the price of grain in the local markets is usually very low. There is one advantage of this system in that the labourer has less chance to drink his wage away; but this advantage is negatived by his tendency to incur debt for the purpose.

The wage in Surat District varies from 1½ anna and one meal per day to 8 annas per day, the lowest wage being paid in the aboriginal forest villages of Mandvi, and the highest in the Ujliparaj villages of Bardoli, Olpad and Chikhli. In Chorasi Taluka I have come across labourers earning from 10 to 12 annas per day when there is scarcity of labour. The wage in kind is generally 5 seers of grain, the rich villages giving wheat and tur, the poorer villages paying in coarser cereals and pulses, usually jowar, paddy, nagli, and wal. In the village of Sathvav the labourer universally receives 2 annas per day and one meal or five seers of grain, except during the season for transplantation when he receives 3 annas per day or five seers of wheat or tur, or extra sweet-oil and salt. The afternoon meal given to the labourer consists of a jug-ful of 'rabro' or 'dhachno', some pulse, usually wal, rice, some pickles and a supply of tobacco.

Up to the famine of 1900 the labourers at Sathvav received a uniform wage of one anna per day and one meal or 5 seers of paddy or kodra. After the famine there was a scarcity of labour and the cash wage was raised to 1½ anna with the usual meal, the wage in kind remaining the same except that wal and jowar were sometimes given, or sweet-oil and salt. This rise in the wage did not increase the supply of labour and in 1902 the wage was again raised to 2 annas per day. The reason why the amount of grain was not increased after the famine was that there was a rise in prices after the famine. The prices, however, fell again, but as the wage had come to be established, it remained at the same level even between 1919 and 1921 when the price indices were as high as 347 and 290 respectively. We thus see that the level of wages of agricultural labour is very steady. This is to the advantage of the labourer so long as he receives the wage in kind, and so long as prices remain high. But when prices are low, it is to the advantage of the labourer to receive his wage in cash.

In aboriginal villages where primitive comradeship is well developed, small farmers exchange their labour according to their requirements and thus avoid the payment of wages. This is called the 'hāndōliā' system. In some cases landlords give meals to labourers when there is no work, on the understanding that they will work for as many half-days during the cultivating seasons. Communal labour is very frequent amongst the aborigines. A hut is usually built with the joint labour of the members of the 'falia' and wages are not charged. The village school was built by the common labour of the village. Small roads or paths are repaired and new ones are built whenever necessary, and water-holes are dug by the members of the village. All houses in the village are repaired annually and the roofs are re-thatched by the common labour of the community. No wages are also charged for building the funeral pyre, for preparing meals for festivals including

marriage, for doing the domestic duties of a household where a woman is in child-birth, and for performing rites for the benefit of the community.

Women go to work together with men in all families of labourers, unless there is no elder child or old person to look after the household and younger children. In families in which there are more females than males, the females earn more for the maintenance of the household than males. Landlords prefer to employ female labour because they say women are more conscientious in their work and they obey orders more readily than their husbands and brothers. Males are preferred during 'nindaman', and the hard toil of breaking the clods is usually left to them. Females help to remove the weeds. Women are employed more than men during sowing, transplanting and picking, whilst men are preferred for ploughing, harvesting and thrashing. Women also run small errands on payment of small considerations in kind.

Children are not employed till the age of twelve, but boys and girls between seven and twelve years of age earn a few rupees every year as herdsmen. They charge two annas per head of every cattle taken to the pasture grounds. Children are also employed for sowing, transplanting, winnowing and harvesting; but they work only as helpers, and heavy work is not exacted of them.

In agriculture the demand for labour is never steady. Labour is necessary for nindāman, (cleaning the fields, breaking the clods and removing the weeds) rōpni (sowing and transplanting), kapni (cutting, reaping and harvesting) and vinvanu (picking). During these periods the supply of labour is sometimes not able to meet the demand and the proprietors have to work at short hands.

The following table shows the maximum demand for labour in the year in an aboriginal village for an estate of about 5 acres or more :—

Type of work.	Maximum number of days during which labour is required.	Minimum number of days during which labour is required.
Cleaning the fields ...	15	10 (end of May)
Sowing and transplanting ...	10	7 (end of July)
Cutting and harvesting* ...	25	15 (beginning of October)
Gathering and picking* ...	20	10 (end of January)
	70	42

* In case of large estates, these periods may be prolonged till the end of February.

From the table we find that the general demand for labour is not very heavy except for the cultivation of paddy, as the rest of the crops can be cultivated by the available labour of the members of the family. Labourers are also required for picking cotton, but as this function is to be performed at the end of the agricultural year, the cultivators could spend more time themselves without employing labour.

As almost the entire village is composed of families of active workers, and as there is no emigration to towns, the supply of labour is usually sufficient to meet the demand. Various rough estimates have been made regarding the number of days in which a labourer in India finds work during the year. Prof. Bhalla estimates it as 278 days, Culvert as 150 days, Dr. Slater as 160 days. I have been able to estimate roughly that an aboriginal labourer is able to find work in his village for 90 full days, 150 half days or one meal, whilst for 125 days he remains without work.

This concludes our investigation into the equipment of the aboriginal peasant for his existence. We have examined land, cattle and implements as the capital of the farmer. These make up his fixed capital.

Under the heading of fixed capital of the cultivator should also be included the following:

(i) Farm-buildings, (ii) wells, (iii) embankments erected to prevent scour during heavy rains and for retaining the moisture in the soil, (iv) fencings, and (v) other improvements made in the lands, viz., field-drainage, wind breaks, manure sheds etc. Of these only the first may be said to have a recurring capital value, the rest may be included as dead stock. Of the last form of capital, only rude field-drainages are found in some fields where land is on a slope or on a low level.

The house in which the family lives is also the granary of the cultivator, and the shed for the cattle. The approximate total values of houses in the village are given below :—

	No. of houses.			
Tiled houses	3	@	Rs. 2000	Total value Rs. 6,000
Houses with corrugated iron sheets.	4	@	„ 800	„ „ „ 3,200
Thatched with areas between 3000-1000 sq. ft.	42	@	„ 60	„ „ „ 2,520
Thatched, with areas less than 1000 sq. ft.	65	@	„ 30	„ „ „ 1,950
Total	114			Rs. 13,670

The circulating capital of the farmer consists of the crop on hand and cash. The farmers usually sell immediately after the harvest, and grains remaining after giving the landlord's share and the interest on debt are stored in 'kōthis' made of cow-dung, dirt and clay. Some of these are 5′ to 6′ high with an area of 32 sq. ft. with a capacity for 2 gallis or 60 mds. of grain. Kodra is sometimes preserved for 6 to 7 years, paddy for three years, whilst the remaining crops may not be preserved for more than two years.

The cultivator is always in need of cash, and even well-to-do khatedars borrow a rupee from the money-lender to buy sweet-oil and vegetables from the weekly market. The average cash on hand with a khatedar of the A class families would be about Rs. 20, with the cultivating tenant not more than Rs. 5, and the labourer rarely keeps a rupee tied in a dirty piece of cloth in a corner of his hut.

The remaining part of the capital of the farmer consists of his personal possessions like ornaments, furniture and utensils, the former being the only kind of saving known to the aboriginal cultivators. Ornaments are of gold, silver, and baser metals like copper, brass, tin, lead and glass. The total value of ornaments in the village in 1929-30 was approximately Rs. 2,320.

Having noticed the value of the various forms of capital of the cultivators of Sathvav, we shall arrive at an estimate of the total capital value of the village.

The total capital value of the village, if it could be sold as a running concern and excluding the purely personal possessions, would be :–

	Rs.	Percentage of each to the total value of the village.
Land	45,955	56·04
Houses	13,670	16·66
Live stock	17,521	21·35
Implements	4,884	5·95
Total	82,030	100

Though this estimate is at best an approximation, it is useful since "it enables us to ascertain the proportion which certain villages bear to capital value and so the relationship which they bear to the conditions prevalent" amongst the aborigines. The following table shows the percentages which certain village figures bear to the total capital value of land and of the village as a whole.

	Percentage on capital value of land.	Percentage on the capital value of the village as a whole.
1. Government assessment of land amounting to Rs. 1,896	4·2	2·3
2. Net village income from all sources being Rs. 16,440.	36·0	20·0
3. Total village expenditure on all things Rs. 18,933.	41·5	22·8
4. Net returns from land being Rs. 8,808.	19·3	10·7
5. Total debts being Rs. 22,022.	48·3	26·8

The above averages show precisely the economic condition of the village community surveyed.

Figures similar to some of these items are available in four other village studies made in the Bombay Presidency.* A comparison between these is of great importance, especially as we get an idea of the comparative condition of the so called civilized and the aboriginal popula-

	Pimpla Sodagar (Deccan).	Jatgaon (Deccan).	Roth Khurd (Konkan).	Atgam (Gujerat) (Ujliparaj).	Sathvav (Gujerat) (Raniparaj).
Percentage of net return of crops on capital value of village.	10·4	10·6	9·58	14·71	10·7
Percentage of total debts on capital value of village.	11·7	22·1	17·7	20·47	26·8
Percentage of Government assessment on capital value of village.	1·27	1·46	0·99	1·79	2·3
Percentage of net village incomes from all sources on capital value of village.	...	...	...	33·22	20·0
Percentage of total expenditure on all things on capital value of village.	...	...	...	32·4	22·8

*The villages of Pimpla Sodagar (Deccan) and Jatgaon (Deccan) studied by Dr. Mann in "Land and Labour in a Deccan Village", studies Nos. 1 and 2; the village of Roth Khurd (Konkan) studied by Mr. Ranade in "A Social and Economic Study of a Konkan Village"; and the Village of Atgam, an Ujliparaj village in the Surat District studied by Mr. Mukhtyar in "Land and Labour in a South Gujarat Village."

tions of the country. In this connection the village of Sathvav may be considered one of the poorest villages, whilst the other villages represent those which are comparatively some of the most advanced economically in the Presidency. The basis of comparison is the percentages which certain village figures in each study bear to the total capital value of the particular village.

Comparing the economic conditions of the above villages, we find that the burden of indebtedness and land revenue is the heaviest on the poorest aboriginal agricultural population. The net income and expenditure of the villagers of a Raniparaj village is about two-thirds in proportion to the income and expenditure of an Ujliparaj village.

Now we shall examine the production, distribution and consumption of crops, the cultivation of which forms the major portion of the peasant's economic activities. The following are the main crops cultivated by the Chodhra farmers:

Food Crops:—Cereals :

Paddy (oryza satina): The following thirteen varieties of paddy are cultivated in the aboriginal villages: Kolambh, dabhel, hutarhal, halyo, malvel, elachi, kalo dangro, torna, kulpo, kalvine, pani bhat, komode, and gudo. Jowar (sorghum vulgare). Jowar is cultivated both as a kharif and as a rabi crop, though the latter is cultivated by only a few farmers. The earliest cultivated cereal, and perhaps the most consumed by the aborigines is kodra (paspalum scrobiculatum). This is a very poor variety of cereal, and its consumption is found to cause intoxication and delirium. The other cereals are nagli (eleusine coracana), banthi, and wheat (triticum aestivum).

Pulses : Tuver (cajanus indicus). This crop is mostly cultivated for export, the most consumed crop amongst the aborigines being 'wane' or beans (dolichos lablab). The other pulses are aradh (phaseolus mungo), grams (cicer arietum) and peas (pisum sativum).

Till the beginning of the present century the Chodhras cultivated only the food crops, but later on they learnt from the neighbouring Kunbis the cultivation of commercial crops. The chief commercial crop of the aboriginal villages is cotton (gossypium indicum). The other crops are castor seeds (ricinus communes), sesamum (sesamum indicum), and Indian hemp (crotalaria juncea).

The processes of the cultivation of crops are primitive. The fields are not properly cleaned or weeded before sowing, and the ground is ploughed only once or twice. Most of the seeds are broadcasted or drilled into the soil by means of a bamboo drill. Hoeing and interculturing are insufficient and the smaller cultivators prefer to leave the fields after sowing till the time of harvest draws near. Harvesting is accompanied by a serious waste of crops on account of inadequate

means of transport. The thrashing floor is prepared in a corner of the fields and a pair of bullocks are made to trample over grains. The methods of husking and winnowing are also primitive and hence a further waste of crops.

The aborigines follow a conventional system of rotation of crops which they have adopted in imitation of the Kunbi agriculturists. The cereals remove much of the plant food from the soil, especially nitrogen, and hence a leguminous crop which absorbs nitrogen from the air is necessary to be cultivated to replace the cereal crops. The following shows the rotation of crops at the village of Sathvav:

Paddy is followed by a mixed crop of jowari and tur. Nagli is followed by aradh. The perennial crop of kapas is followed by jowari. Wheat is cultivated in talavris and kyaris for four to five years successively, followed by a crop of grains and castor-seeds. Kodra is cultivated successively for two years, followed by a crop of castor-seeds or wal which is followed by wheat the next year. Crops cultivated in talavris are usually not changed.

In order to prevent an exhaustion of the soil, fields are kept fallow after certain periods and are allowed to regain the lost plant-food from the atmosphere and to make the dormant plant food in the soil active. As the cultivable area is limited and as there is a pressure of population on the soil, fields in the aboriginal villages are allowed to remain fallow only when they get completely exhausted and are not able to yield any crop. Usually the fields are allowed to remain fallow after four or five years. In some cases, instead of allowing the soil to remain fallow, san is cultivated and ploughed into the soil, or a crop of castor-seeds is found sufficient to revive the soil.

If the soil of the agriculturist must remain fertile, the constant replenishment of the substances withdrawn from the soil for plant nutrition is necessary, and this is achieved by manures. Fertility of the soil depends upon the physical properties of the soil, aided by the bacterial processes which go on within it, and lastly by the actual composition of the soil. It depends upon the pulverisation of the soil into minute particles. Manures should be such as to render the insoluble particles available for plants, destroy the denitrifying bacteria and arrest the fermentation after the above ends are attained. They should also add bacteria and chemical food to the soil. The Chodhras are accustomed to use whatever farmyard manure is available. They collect cow dung, farm rubbish, leaves and whatever comes handy outside their huts, and before the time for sowing this rubbish is applied as top-dressing to the fields. Green manuring takes place through the rotation of crops, but the full benefit of the leguminous crops is not given to the soil as the leaves of the plants are used as fodder for the cattle. The use of human urine and excreta as manure is not known

to the aboriginal farmer. Ashes are used as manure for the nagli crop. Most of the manure given to the fields is wasted on account of the uneven surface of the soil and the incapacity of the plough to penetrate into the sub-soil.

The quality of the crop depends considerably upon the quality of the seed sown by the cultivator. 'The whole cultivation of India has been based upon seeds stored promiscuously by the farmer or supplied by the Bania, whose only anxiety is always to get the highest possible price for the cheapest possible article." The aboriginal cultivator invariably sows the seeds of the previous year, whilst seeds for the commercial crops are usually brought from the money-lender at one hundred per cent interest to be repaid in kind the next year. The farmer selects the best ears of corn or sheaves to be utilised as seeds in the following year, but in many cases they are spoilt during the year by insects, or due to climatic conditions. The quantity of produce is also affected by the constant danger from animals, birds, insects, pests, and fungoid diseases. The Chodhras maintain that almost one-third of the crop is destroyed by wild boars, monkeys and sparrows. In most cases the fields are fenced—in some cases a number of fields are fenced together by bawal, medhi, danta or thuver. But these are not strong enough to face the thick-skinned wild boar or the agile monkey.

The greatest friend or enemy of the crops is rainfall. We have noticed before the average rainfall at Mandwi, but more important is its distribution.

The following table shows the distribution of rainfall by months in Mandwi Taluka between 1925-1930.

Period.	1925	1926	1927	1928	1929	1930
Before May ...	1·50	0·39	0·12	...	0·28	...
June ...	18·67	0·54	14·13	1·29	4·95	10·70
July ...	11·51	29·64	25·40	23·83	18·78	24·33
August ...	5·69	42·38	8·34	10·55	8·16	5·52
September ...	0·92	7·20	4·89	6·91	2·28	6·81
October ...	...	...	2·55	0·15	0·21	0·61
November ...	0·40	...	2·35	0·10	...	...
December ...	0·4	...	...	0·3	0·62	0·13

The ignorance of the people and the irregularity of their agricultural operations make it impossible to arrive at a very correct estimate of the rainfall required at particular periods. The following table is however made out from one prepared by Mr. Mukhtyar when investigating the economic conditions of a village in Chikhli Taluka in the same District.* Alterations have been made to suit the local conditions and habits of the agriculturists of the Mandvi Taluka.

* Mukhtyar: Life and Labour in South Gujarat Village, p. 27.

Period.	Required rainfall.	Why necessary.	Actual rainfall.				
			1925	1926	1927	1928	1929
	In inches.		Inches.				
June 10–20	8	Preparing soil for sowing	1·65	0·10	10·68	1·21	2·51
June 26–30 –4th July	2	Broadcasting seeds of paddy and cereal crops.	5·62 ·22	0·35 2·23	0·22 0·68	0·8 1·74	... 0·34
July 1–10	7	Necessary for the growth of seedlings of paddy, and other coarse cereals.	1·72	6·68	5·82	7·23	3·83
July 10–20	10	Necessary for making beds for sowing paddy seedlings after transplantation. The bed must become soft and muddy.	6·67	10·96	7·77	9·31	13·56
July 20–31	3	For transplanting paddy and other seedlings.	3·11	12·0	12·21	7·29	1·39
August 1–31	10	Necessary for all crops...	5·69	42·38	8·34	10·55	8·16
September 1–30	10	Necessary for rabi crops	·92	7·2	4·89	6·91	2·28
October 1–31	2	Useful for rabi crops ...	...	...	2·55	0·15	0·21
Rainfall required 52″.							

We conclude from the above that (i) Rainfall in the early part of June, which is required for preparing the soil is insufficient in four years, whilst rainfall necessary for broadcasting seeds in later part of June is sufficient in two years out of five. (ii) Rainfall necessary in the middle of July for broadcasting seeds is sufficient in two years out of five. (iii) Rainfall in the later portion of July, necessary for the transplantation of paddy and other seedlings is over-sufficient in three years out of five thus prematurely destroying the seedlings. (iv) Rainfall in August is sufficient in two years out of five. The excessive rainfall in this month is not injurious to the crops. (v) Rainfall is insufficient in the months of September and October when it is necessary for the rabi crops. (vi) The sudden showers of rain in December and January spoil the rabi crops and sometimes the kharif crops which happen to be on the thrashing floor.

The supply of water is further replenished by lift-irrigation. We have noticed before that the Chodhras secure water from water-holes, wells and tanks. However, with some exceptions, these are never useful

for irrigating the fields as there are no appliances for drawing water, and the wells are far away from the fields.

We shall now proceed to investigate the extent of cultivation of the various crops. The following tables show the area under cultivation in the Mandwi Taluka between 1873 and 1900, and at the village of Sathvav in the year of inquiry. (See Table A)

We find that there has been a general tendency in Gujerat to cultivate less food crops and more of commercial crops during the last thirty years, a tendency which has been more prominent in Surat than in any other District of British Gujerat.* However both in Mandwi and Sathvav we find that the cultivators grow more of food crops and less of commercial crops, the ratio being approximately three to one. This is mainly due to the following reasons :

(1) The soil and climate is not good for commercial crops.

(2) The aborigines are not able to produce such quality of commerical crops as can compete with the produce of the neighbouring Districts and Talukas on account of their primitive methods of cultivation and inefficient implements ; and therefore the local merchants are not willing to purchase the crops.

(3) Commercial crops require more capital to be invested than the food crops.

(4) The aborigines are always in want of cash, and therefore they must produce sufficient food-crops to satisfy their family demands without resorting to the market.

(5) There are no trading and commercial facilities. The forest villages are away from big market towns, railways, and post and telegraph offices.

* The following table shows the food and non-food crops raised in the various Districts of British Gujarat in 1895-96 and 1926-27 :

District.	1895-96		1926-27	
	Food.	Non-Food.	Food.	Non-food.
Ahmedabad ...	72	28	64	36
Kaira ...	92	8	68	32
Panch Mahal ...	91	9	70	30
Broach ...	49	51	43	57
Surat ...	77	23	38	62
Gujerat ...	75	25	58	42

(6) Another reason for the aborigines continuing to grow food crops as before and not venturing to grow commercial crops for the sake of profit is the force of custom and habit in the aboriginal tribes. The Chodhra prefers to till the same crops sown by his forefathers to venturing on fresh enterprises which may result in starvation.

The following are some of the chief features of the cultivation of crops at Sathvav :

(1) Paddy and jowar are the two most important cereals which are cultivated by the aborigines. The crops are gradually replacing the coarser cereals like kodra and nagli. We find that in 1873 the coarser cereals were grown in almost equal quantity with paddy. Almost half the cultivated area is sown with cereals.

(2) Tur, grain, peas and aradh are the chief pulses cultivated at Sathvav in their order of importance. The pulse crops tend to increase with the growing cultivation of these as mixed crops together with cereals and commercial crops.

(3) The poor cultivation of vegetables, tobacco, spices etc. is due to the absence of sufficient water-supply and irrigation. The aborigines cultivate vegetables in small areas for home consumption.

(4) Castor-seeds and cotton are the two main commercial crops which are cultivated alternately. Cotton growing is now neglected by the aborigines on account of low prices, and the risk involved due to sudden frost in December.

We shall now consider the quantitative aspect of cultivation, or the crop yield in the village of Sathvav. It is most difficult to find the total yield of crops of a whole village, because the aborigines do not keep accounts of the various crops as they are harvested. However, I have roughly estimated the total crop yield of the village of Sathvav in 1928-1929 and 1930-31 from the estimates of the produce of various crops supplied to me by 77 families residing in the village. From this estimate I have found the total value of crops cultivated in the village and the yield per acre of each crop.

		1928-29		1930-31	
Crop	Yield per acre in Mds.	Produce in Mds.	Value of crop in Rs.	Produce in Mds.	Value of crop in Rs.
Grains:					
Paddy ...	12	3,108	5,439	3,702	3,702
Jowar ...	3½	976	1,330	395	665
Wheat ...	7	70	192½	238	476
Kodra ...	7	665	665	532	332½
Nagli ...	15	615	1,076¼	1,095	1,095
Banthi ...	30	210	210	150	93¾
Total grains:	...	5,644	8,912¾	6,112	6,364¼

		1928-29		1930-31	
Crop	Yield per acre in Mds.	Produce in Mds.	Value of crop in Rs.	Produce in Mds.	Value of crop in Rs.
Pulses :					
Wal ...	8	448	672	824	824
Tur ...	14	1,078	2,695	588	1,176
Gram ...	8	92	253	752	1,504
Peas ...	4	60	105	496	496
Aradh ...	8	344	688	328	492
Lang ...	...	30	37½	9	9
Mag ...	...	10*	10	1½	1½
Chora ...	...	10*	7½	...	1½
Total pulses ...		2,072	4,468	2,998½	4,502½
Til ...	...	5	15	9½	23¾
Tobacco ...	...	¾*	5	½*	5
Mor ...	...	...	...	7½	8
Bhadli ...	...	10*	1	10 *	1
Chiles ...	...	5*	8	5	8
Gowar ...	...	5*	5	5*	5
Total ...		25¾	34	37½	50¾
Cotton ...	3	405	2,430	150	600
Castor-seed ...	4	296	814	648	1,296
Hemp ...	...	45	56¼	120	120
		746	3,300¼	918	2,016
Grass ...	...	70,000 pulas	770	60,000 pulas.	570
Gross value of crop.	...		17,485	...	13,503

Thus the gross income from agriculture per head of population in the village of Sathvav in 1928-29 and 1930-31 comes to Rs. 27-12 and Rs. 21-8 respectively and the gross income per acre of cultivated land in the same year comes to Rs. 13½ and Rs. 9.

The yield per acre is also very low. The yield per acre at Sathvav of food grains including both the cereals and pulses is 9·8 mds. per acre. Thus the yield per acre in the village of Sathvav is about half the yield per acre of Gujerat and one-third the average yield of India of eight years ending 1920.†

* Approximate estimates.

† We find that the yield per acre of crops at Sathvav is very low. In Statistics of India of 1921 in No. 1334, the average yield per acre for eight years ending 1920 for the undermentioned crops is as follows :

Paddy	885 lbs.	31 mds.
Jowar	500 lbs.	18 mds.
Wheat	690 lbs.	24 mds.

The general causes of low yield per acre in the aboriginal villages is due to primary causes like the ignorance of the people, want of capital, indebtedness, burden of land revenue, bad soil, want of irrigation, the force of custom in determining the methods of cultivation and inefficiency of labour. But the following special causes may also be mentioned :

(1) Uncertain and not well distributed rainfall.

(2) Fragmentation of holdings.

(3) Insufficiency and bad breed of cattle.

(4) Primitive implements used by the aborigines.

(5) Absence of manure, want of proper weeding, sowing and ploughing of the fields, bad or not properly selected seeds.

(6) At least about one-sixth of the total produce, according to the aborigines, is destroyed annually by crop diseases, insects, birds and animals on account of inadequate protection of the crops.

(7) Pressure of population upon the soil.

(8) Perhaps the chief reason for the low yield of crops is absentee landlordism. The lands belong to persons who have very little interest in the soil, and hence they do not attempt to make improvements on their estates. The cultivators have neither the capacity nor the inclination to improve their cultivation.

Having measured the economic value of crops, we shall now measure the actual benefit in kind derived from cultivation by these farmers. The following table shows the distribution of the total crop produce of 77 families of cultivators residing in the village of Sathvav according to the amount paid in kind as interest on debts incurred, the amount paid in kind as rent, the total amount sold and the amount left for consumption at home in 1930-31 : (See Table B)

From the previous table we find that almost one-fourth of the total crop, and more than one-third of the commercial crop is given over to the money-lender for the payment of debts, and the interest accrued upon it.

The average yield per acre of food grains in Gujerat between 1891 and 1926 is as follows :—

Years.	Annual average yield of food grains in Mds.	Annual average acreage under food grains	Yield per acre in Mds. of 40 seers.
1891-1900	43,553	2457	17·7
1901-1910	42,572	2233	19·1
1911-1920	35,148	2051	17·1
1921-1926	22,471	1328	16·9

Mukhtyar : Life and Labour in a South Gujarat Village.

It appears that about 15% of the crop is given as rent to the landlords. This, however, is not quite true, because the landlord is usually the money-lender who exacts his rent and interest on debt together, and therefore he always calculates that the crop surrendered to him is almost sufficient to cover the interest and part of the rent. The remaining part of the rent due is credited to the amount of debt which has yet to be paid.

The cultivators are able to sell barely 8% of the total produce and 36% of the commercial produce to the market. To this should be added some amounts of grain which are sold in the local market from the crops left for their consumption whenever the cultivators are in urgent need of small cash. It is not possible to measure this amount as no records of such sales are kept by the cultivators. The amount realised from the sale of crops is usually spent in the payment of Land Revenue, purchasing clothes and payment of cash wages. The following table shows the amount of value of crops exported from the village in 1930–31:

	Cereals.		Pulses.		Commercial.		Total.	
	Mds.	Rs.	Mds.	Rs.	Mds.	Rs.	Mds.	Rs.
Sold by the cultivator	220	351	157	233	270	574	647	1,158
Paid to the money-lender as interest on debt.	996	1,085	796	1,307	251½	643	2,043½	3,035
Paid to absentee land-lord as rent.	840	946	356	440	95	209	1,291	1,595
Total crop sold. ...	2,056	2,382	1,309	1,980	616½	1,426	3,981½	5,788

Therefore the percentage of export to the total produce of the village is 39·7% which values at 42·1% of the gross value of crops produced in the village. We conclude that whilst there is a shortage of food grains in the village, the village exports nearly one half of its produce. Export of grains is desirable when there is a surplus of produce with the farmer, "but owing to the condition of the country, our ignorance, poverty and industrial backwardness, our export trade, especially of food stuff is being maintained at the expense of the health and comfort of the producers."

We should notice that the main causes of this undesirable export of food grains to foreign markets are absentee-landlordism, indebtedness, the systems of cash payments, and the payment of rent in kind.

Of the 54% of total crop which is left for home consumption, a part has to be set aside for small sales, payment of rent in cash, payment of Land Revenue and seeds. This portion also includes wages, but as these again go to feed the population of the village we calculate that about 35% of the total crop produced by 77 families is used for the maintenance of the whole population of the village. To this must be added the wages earned by 37 families from landlords not residing in the village. This amount may be roughly estimated at 100 Mds.

The total annual food supply of the village in 1930–31 could be, therefore, roughly estimated to be :

Cereals	...	...	3600 Mds.
Pulses	...	...	1300 Mds.

The total minimum grain requirements of the village for 236 males, 229 females and 132 children (infants are excluded as they are not given grain as food) is :*

Cereals	...	...	4950 Mds.
Pulses	...	...	1920 Mds.

Thus there is a shortage of grain supply in the village. This shortage is made good by grains preserved from the produce of the previous year, purchase of crops from market, or 'khavti' borrowed from the richer landlords to be returned at 50% interest.

Not only there is a shortage of food supply in the village ; but the grains left with the cultivator after sale and payment of debt and rent are of the coarsest variety and of poor quality. Almost the whole of the wheat produce is taken away by the money-lender in return of interest or rent. The amount of paddy and jowar left with the ciltivator for domestic consumption is about 60%, whilst about 85% of coarse cereals like kodra, nagli and banthi remain to form the daily food of the aborigines. The aborigines consume a bigger portion of wal, aradh and tur and lesser quantities of grams and peas which are pulses of a better variety.

We shall now investigate the income or loss of peasants in their agricultural occupation. The following statement shows the income and expenditure of the cultivators of Sathvav village and the net income from their occupation in 1928–1929 :

*We have considered the consumption capacity of a male to be 7/16, of a woman to be 5/16, and of a child to be ¼ of the whole unit. The average annual capacity of the male is calculated by us to be 460 seers of cereals and 168 seers of pulses.

Income:				Expenditure:			
Value of total crop produce.	Rs.	21,107	2	Wages ...	Rs.	1,763	4
Fodder ...	„	1,303	2	Land Revenue ...	„	941	12
Manure ...	„	335	12	Rent ...	„	4,154	0
Income from cattle ...	„	554	4	Seeds ...	„	1,447	0
				Manure ...	„	396	4
				Transport ...	„	228	8
				Plough hire ...	„	290	0
				Implements ...	„	266	12
				Cattle-feed ...	„	2,590	8
				Pasture-fees ...	„	33	0
				General on cattle	„	128	8
				Depreciation on bullocks ... (Taking the average life of a bullock to be 15 yrs.)	„	790	0
				Interest on capital (@ 4% interest on land and cattle)	„	1,454	0
				Net income ...	„	8,816	12
Total	Rs.	23,300	4	Total	Rs.	23,300	4

From the statement we notice that the cultivators receive only 16% income on their total capital. The average annual income per family of cultivator comes to Rs. 90-8. As the average size of the household in the village is 6 persons, the average daily income per head of population comes to 8 pies per day or annas 4 per household.

The conditions described before would ordinarily conclude the investigation of the economic life of the people; but our study is incomplete if we do not consider certain important factors which deprive the peasant of the small fruits of his labours, and become the direct or indirect cause of his chronic poverty.

The chief burden on the agriculturist is indebtedness. In many cases the supply of cheap grains fails before the beginning of the new year, so that the cultivators and the labourers are forced to seek the doors of the money-lender to borrow food-grains and seeds to suffice till the next harvest when the loan has to be returned with fifty per cent more grains than the quantity borrowed. The money-lender comes down on the cultivators at harvest time and demands his dues, taking

away the most he can by way of interest and rent, leaving a bare minimum for their subsistence.

The total burden of indebtednes of the families residing at the village of Sathvav is Rs. 22,022 distributed in the village as follows :—

Cash debt of peasant-proprietors		Rs.	18,588
Cash debt of cultivators other than peasant-proprietors.		„	2,966
Cash debt of labourers	Rs. 97		
Debt of food grains of labourers ...	„ 371	„	468
	Total	Rs.	22,022

The total number of indebted families in the village is 82; 48 peasant-proprietors, 29 cultivators and 5 labourers—so that only 32% of the families residing in the village are free from debt, of which 21% form the families of cultivators.

The average debt per family is ...	Rs. 191
The average debt per indebted family is ...	Rs. 286
The per capita debt is about ...	Rs. 35
The debt's multiple of Land Revenue is ...	12·5
The debt per cultivable acre of land in the village is...	16·6

The following is a detailed analysis of the total cash indebtedness of the village :

Free from debt	37
In debt :	
Below Rs. 50	15
From Rs. 51 to Rs. 100	12
„ Rs. 101 to Rs. 200	12
„ Rs. 201 to Rs. 300	14
„ Rs. 301 to Rs. 400	5
„ Rs. 401 to Rs. 500	6
„ Rs. 501 to Rs. 600	2
„ Rs. 601 to Rs. 700	2
„ Rs. 701 to Rs. 800	0
„ Rs. 801 to Rs. 900	1
„ Rs. 901 to Rs. 1000	2
„ Rs. 1001 to Rs. 1500	2
Above Rs. 1500	1
Amount not known	3
	*114

* Two families are jointly indebted, and hence are considered as one family.

Of the unindebted families 9 are peasant-proprietors, 11 are cultivators and 17 are labourers. It should not be supposed that the absence of indebtedness is due to sound economic conditions. In most cases the families have no security to offer, and are therefore refused loans. Four of them have been lately freed from debt.

The heaviest burden of debt is found to be on the peasant-proprietors.

Debt per family of peasant-proprietor is about	Rs.	350
Debt per family of cultivator is about	Rs.	75
Debt per family of labourer is about	Rs.	5

Whilst the labourer is not often in need of cash, and even if in need, he is not able to obtain it, he is very often in need of food. During 1928-29, 28 families had borrowed grains as "khavti" to the value of Rs. 248.

From the above facts we gather that the more prosperous a family is, the greater is the burden of indebtedness. The labourer usually borrows small amounts, and the creditors are in most cases their landlords who do not always care for the repayment of the loans, or they secure the payment of the loan in terms of labour. The labourer has no credit and therefore no loans are advanced to him by the money-lenders. The paucity of their needs and the comfortable habit of forgetting their small debts also contribute to the comparatively small indebtedness of the poorer classes.

The villagers do not keep any accounts, nor have they a good memory to remember why a certain amount was borrowed on a particular day. The system of borrowing resembles a current account system where the cultivator borrows when he is in need of money, and delivers grains to the money-lender when the harvest is ready. The following are the chief causes of debts which have been so far incurred in the village in order of their importance.

(1) Need of cash after the famine of 1900.

(2) For marriage expenses including the payment of the bride-price and money necessary for the marriage ceremony and feast.

(3) Need of cash for small purchases at the market and payment of tailor, cobbler, potter, blacksmith etc.

(4) For the payment of Land Revenue.

(5) Debt incurred due to shortage of food.

(6) Debt accumulated for drinks taken on credit.

(7) Borrowing of seeds at the beginning of the agricultural season.

(8) Money necessary for the purchase of cattle, especially bullocks and buffaloes.

(9) For building houses.

(10) For defraying expenses on illness of members of the family and cattle, and buying offerings for the gods and spirits.

(11) For paying expenses of litigation.

We notice that the majority of debts are incurred for unproductive purposes, and debts are never incurred for investing money in order to obtain more income. It is necessity alone which drives the cultivator to borrow money for buying cattle, building a house or sowing seeds whilst the chief burden of debt is due to comparative exorbitant expenses on marriage, purchase of ornaments of base metals, and such other social and religious purposes. The original burden of debt is, however, due to the famine of 1900, when people mortgaged their lands and ornaments in order to buy corn. The words of Darling appear to be true of the people of this village that "in all agricultural countries it was with the hunger engendered by famine that money-lending began."* The amount borrowed is usually small, varying from Rs. 100 for a marriage, Rs. 70 to 40 for a bullock, to a few annas for purchasing sweet-oil and salt from the market.

Debt once incurred tends to accumulate for various reasons. The most important factor which contributes to the accumulation of debt is that it is inherited by the successive heirs as a legacy from the dead. There have been many cases in the village when land was appropriated by the money-lender as the debtor had not paid his debts before his death. It is at the time of the occurrence of a death, that the money-lender has the real opportunity to fulfil his much calculated wish to possess land. The system of keeping accounts and the method of counting debt is another reason why debt tends to accumulate. When a cultivator first borrows money an account is opened in his name in which loans and interest are credited to his account, and all payments are debited. The debtor is orally informed annually of the extent of his indebtedness. The perpetuation of debt is finally completed by the system of paying the original sum and the interest charged upon it in kind. The local price of grain is very low, and therefore giving the maximum amount of crop to the money-lender he is never able to pay the full amount due. To these important factors should be added the desire of the money-lender to keep his debtor perpetually in bondage, and the belief of the creditor that a good cultivator can never be free from debt. The money-lender takes every precaution to see that the money due to him is never paid up in full, and very often he makes gratuitous offers of loans under the cloak of most honourable intentions of being of service to his client.

The impoverishment of the peasant-proprietors, caused by indebtedness is further increased by the heavy burden of Land Revenue. We have noticed already that till the advent of the British, the aboriginal

* Darling: *Punjab Peasant in Prosperity and Debt*, p. 198.

cultivators paid a mere quit-rent to the State. Even where a heavier charge was made upon the crops, the revenue was never imposed without a previous consultation between the officer of the State and the proprietor. In the *Bombay Gazetteer* we are told that the " Kamavisdar " a Mamlatdar proceeds in person to the different villages, assembles the cultivators, and settles the amount of their holdings.* Up to 1848, when Mandwi was ruled by Rajput Princes, the villages were farmed out for a term of years or let to the Patils on an Udhar jamabandi, which was increased from time to time, or the lands were let out to cultivators on the Khatabandi, plough tax or crop rate systems and the revenue levied in kind on the Bhagabatai principle.† Since the Taluka came under British rule, a bighoti system was gradually introduced in all villages. The history of the administration of land in Surat District from the first British occupation up to the introduction of the present survey system of land when the revenue came to be collected direct from the cultivator, may be divided into three periods :— (1) 1816-1833, when the rates previously in force were continued; (2) 1831-63 when the rates were from time to time raised by the District Officers: (3) 1863–76 when under the working of a special survey department, the lands of the district were remeasured and fresh rates of assessment introduced. ‡

The settlement of Mandwi was the last undertaken by the Gujarat Revenue Survey Department in 1873. The original settlement was introduced experimentally for one year in 1871–72, and subsequently guaranteed by Government Resolution No 6507, dated the 29th November 1873, for the full period of 30 years.§

The following is a brief survey of the amount of assessment in the Mandwi Taluka since 1852:

1851–52	...	Rs. 79,188
1861–62	...	„ 94,962
1870–71	...	„ 1,28,396
By First Settlement survey (1873)		„ 1,51,062
By Second Revision Settlement Survey (1904)	...	„ 1,63,662
1924–25	...	„ 2,06,792
1928–29	...	„ 1,97,323

From the above figures it would appear that the people must be continuously experiencing prosperity in agriculture, but the reverse has

* Mr. Stubb's letter dated 13-11-1828 quoted by. Campbell: Bombay Government Gazetteer, Vol. II, p. 218.

† Original Revision Survey Settlement Report of 1872 quoted by Cole : Revision Survey Settlement of Mandwi, 1904, p. 44.

‡ *Cf.* Campbell: Bombay Presidency Gazetteer, Vol. II, pp. 217–18.

§ Cole: Revision Survey Settlement Report of Mandwi, 1904.

been the case. In spite of arrangements under which cultivators of the dark races held land at especially easy rates, their condition in 1850 would seem to have been wretched in the extreme. The landholder of this class was at that time described as "a prey to the money-lender, who eats the hard earned profits of his labour. The very seed he sows is often not his own, and the rates of interest he has to pay leave him with only a bare subsistence of the coarsest grain."* Whether an increase in the land revenue has been justified in later years can be judged by the economic condition of the people as it is at the present day. The cultivation of the aboriginal is poor, his indebtedness is heavy, and there is considerable loss in the occupation of agriculture, and therefore the increase in land revenue must have been based on miscalculation or wrong estimation of the real condition of the people. The Settlement Officer, when recommending an increase in land revenue, usually forwards the following arguments in suggesting an increase:

(1) Rise in the value of land as evidenced by sums paid for occupancy rights and rent.

(2) Rise in the prices of staple products, or rise or fall in the purchasing power of money.

(3) Increase in the number of ploughs, bullocks, carts, number of built or tiled houses.

(4) Improvement in facilities for transport, building of new roads, construction of railway, and advent of motor transport.

(5) Decrease in the number of notices to pay land revenue.

(6) Regularity and amount of rainfall.

Thus the standard adopted for testing the prosperity of the people is quite erroneous, and the increase can in no way be justified for the following reasons:—

(1) Rise in the value of land as evidenced by sums paid for occupancy rights may only be due to competition or the enterprising nature of individual peasants; and the rise in the rental value of land may be due to an increase in the available supply of landless cultivators.

(2) The aboriginal cultivators rarely profit by the rise and fall of prices as they produce very little for export, and the benefit, if any, is enjoyed by the money-lender. Cash transactions are rare, and hence the rise or fall in the purchasing power of money does not affect much the aboriginal cultivator.

(3) If necessities like ploughs, bullocks and carts are to be taken as signs of the prosperity of the peasant, and if increase of land revenue should be based on such factors, then it amounts to virtual taxation of the productive investment of capital by the peasant, which is never the

* Cole quotes a letter of A. F. Bellassis, the First Assistant Collector of Surat, No. 42, dated 15-10-1850.

object of land revenue. To tax the people because they wish to live in decent houses, is to prevent the rise in the present miserable standard of life of the people.

(4) A mere improvement in transport may only be due to the urban population attempting to invest its capital in rural areas. Better transport is of no use to the people unless they are able to make use of it and unless there is sufficient demand and supply of produce for distant markets. In most cases, at present, motor transport and better roads are only of service to the money-lenders who collect the grains of the people.

(5) It is unjust, if not strange, that people should be taxed for somehow managing to pay their land revenue dues to the Government when they are due. In most cases the money is borrowed and paid on account of the fear of attachment of land, cattle and moveable properties which will leave the peasant destitute and homeless.

(6) That people should pay more land revenue because there is sufficient rain, would almost amount to saying that they should welcome famine.

That the revenue assessed is heavy can be more definitely judged from the following:

The average burden of land revenue per landed proprietor is	Rs.	21·8
" " " per family residing in the village is ...	"	16·5
" " " per plough is ...	"	15·5
Incidence of land revenue per head of population in the village is Rs. 2–9, whilst the average annual income is ...	"	26·0

The above figures are too eloquent for any criticism. The burden of revenue is too heavy for the gradually impoverished peasant to bear. A large amount of the money paid as land revenue is borrowed from the money-lender and hence the Land Revenue charge will include the 12½% compound interest together with the evil consequences of indebtedness detailed before. The net results of the heavy burden of land revenue upon the people is a heavy decrease in the income of all classes of people, for the burden of Land Revenue is distributed by the peasant-proprietors and the absentee-landlords indirectly between the tenants and labourers also. The maximum burden of land revenue, however, is felt by the most important members of the agricultural community, viz., the small peasant-proprietors.

We shall now briefly put forward the statistics available with us to present a complete and compact picture of the economic conditions of the people. The economic conditions are measured by the income and expenditure of the people, indebtedness being merely the consequence of an excess of the latter over the former.

So far as the income of the people is concerned, land, labour and cattle are the principal sources of income. We have divided the income from labour under two heads, the income from skilled labour, and the income from unskilled labour. The receipts of skilled labour are usually from spinning, weaving, mat-making, broom-making etc.

As regards the expenditure side, the items in order of importance are cost of living, interest, expenses on occupation and land revenue.

There are 115 families in the village and four other persons living in the Gandhi Ashram. We have rejected from our investigation the information obtained from three families, and from the inmates of the Ashram as a consideration of these would have prejudiced the correctness of our conclusions.

The following figures show the annual income and expenditure of the 112 families comprising 618 individuals :—

Income.	Amount in Rupees.	Percentage of each to the total income of the village.
Income from land ...	11,379	69·3
Income from cattle ...	900	5·5
Income from labour ...	3,038	18·4
Income from spinning and weaving ...	206	1·2
Income from other subsidiary occupations ...	917*	5·6
	16,440	100

Expenditure.	Amount in Rupees.	Percentage of each to total expenditure.
Cost of living ..	13,010	68·7
Expenses on repairs of implements ...	267	1·5
Land Revenue ...	951	5·0
Interest charges ...	4,163	21·9
Supplementary expenses ...	542	2·9
	18,933	100

The approximate total indebtedness of the village amounts to Rs. 22,022. It is obvious from the above figures that there is a deficit in the income of the people. A more clear view of the situation will be given by the following figures :

1. The average size of a family in the village is 5·5
2. The average annual income per family is about Rs. 146
3. The average expenditure per family is about ... 169

* Rs. 555 is income from a toddy booth owned by a Parsi residing at Sathyav, in another village.

4.	The average indebtedness per family is about	...	196
5.	Per capita income is about	... ...	26
6.	Per capita expenditure is about	... ...	30
7.	Per capita indebtedness is about	... ...	35

It is thus evident that the average family at Sathvav is barely able to eke out its existence.

The poverty of the people is complete, the level of minimum subsistence may be well regarded as surpassed. The peasant-proprietor is reduced to serfdom, and his happiness is threatened by a money-lender whose ignorance prevents him from seeing the growing despair and desperation of his victims. The only help that such a people can expect at this critical period is from the Government of the country. The only relation that exists at present between the rulers and the ruled is the unrelenting demand for revenue. Otherwise the interest of the people are sadly neglected. Whilst Governments are holding conferences for debt moratoriums, when nations are defaulting, the poverty stricken peasants are left to be deprived of their all by landlords and money-lenders. Whilst there is a toddy booth or a liquor shop in the most distant villages, children have to walk for miles to attend a small hut in which a miserably paid teacher conducts three to four primary classes. Medical relief is sometimes 30 to 40 miles away from the villages, and three medical men attend to the needs of a population of about 80,000 people. Maternity aid is conspicuous by its absence, the village roads are in a miserable condition, the people yet drink water from dug water-holes whilst the cattle drink the stagnant waters of a tank which was repaired a decade ago. Left in ignorance, the people yet use the most primitive implements and cultivate coarse grains for their maintenance with the most primitive methods. There are no pastures for the cattle, there is no manure for the fields, there is no protection for the people from the wild boars, the monkeys, the money-lenders, the liquor vendors and petty officials who carry on their cruel exploitation of a weak, ignorant and defenceless people in their respective spheres.

The prospects for the future are dark and grim indeed, and it is impossible to say from where will come their salvation at a time when the relations between the people and the government are strained to the extreme and are only maintained by the very delicate thread of coercion.

B. H. MEHTA

Reviews

The Age of the Imperial Guptas. The Manindra Chandra Nandy Lectures, 1924, (Revised by the author in 1929-30). By the late PROF. A. D. BANERJI, M.A., Manindra Chandra Nandy Professor of Ancient Indian History and Culture, Benares Hindu University. Formerly, Archæological Superintendent, Eastern Circle, Calcutta. Published by the Benares Hindu University, 1933.

It has been the sad fate of the late Prof. R. D. Banerji not to be able to see his last works. Shortly after his death his monumental work on the History of Orissa saw the light of day. That was followed by Vol. XLVII of the Archæological Survey of India, Imperial Series, on *The East Indian School of Mediaeval Sculpture.* And now the University of Benares, to which he devoted the last energies of his already enfeebled constitution, offers to the public another posthumous work of that great archæologist, critic and historian.

The volume embodies six lectures delivered at the University of Benares in 1924, but finally revised by the author shortly before his death. Dr. A. S. Altekar, his successor as Manindra Chandra Nandy Professor of Ancient Indian History at the Benares Hindu University, has carefully edited the book.

It was not the intention of Prof. Banerji to offer a new chapter in Gupta political history when he delivered his first lecture. Yet there is no doubt that there is something new in it, if not as regards the facts themselves, at least as regards the exposition of these facts. The split up of the Gupta Empire after the death of Skanda Gupta is a fact well known to all the students of ancient Indian History; but nowhere is this event explained so lucidly as in this first lecture of Prof. Banerji (pp. 51ff). Similarly, Prof. Banerji exposed his new views about the Śaka king slain by Chandragupta II. He thinks that "the last great Kuṣāṇa Emperor was killed in his palace of Mathurā by Chandragupta II" (p. 30). The editor of this book, Dr. Altekar, is of a totally different opinion on this point (*Cf. J. B. O. R. S.*, XIV. pp. 250-252), though the author does not refer to his views in this particular place. And indeed even if admitting that the Śaka King referred to in the *Devī-Chandragupta* is the Kushāṇ King, yet one cannot agree with our author's opinion that at this time "Mathurā was still the capital of the

great Kuṣāṇas" (Ibid.). This is a statement without foundation and has against it the whole epigraphical evidence of the period.

Prof. Banerji seems to be a little too harsh when passing the final criticism on Kumāra Gupta I. "Kumāragupta I", says he, "the fourth emperor of the Gupta Dynasty, cannot be compared to his father and grandfather. He was probably weak in character and fond of a life of easy indolence. In the absence of official inscriptions of his reign, like the Allahabad pillar inscription of Samudragupta or the Bhitari pillar inscription of Skandagupta, it is extremely difficult to assert anything with certainty. But the general trend of events of his reign and the subsequent disruption of the Gupta empire in the time of his second son, Puragupta, indicates that he was no intrepid leader of men like his grandfather or a notable general like his father" (p. 41). Perhaps, Prof. Banerji did not accept the authority of the Saurashtra folk-lore, according to which Kumāra Gupta was sent by his father to conquer Saurashtra, and after doing so he appointed one Chakrapani as his viceroy of the newly conquered country and returned to his father's kingdom (*Cf.* Thomas, *Records of the Gupta Dynasty*, p. 15). A prince who conquered Saurashtra at the injunction of his father cannot be called "weak in character, and fond of a life of easy indolence". Moreover, according to my calculations this Emperor, was the founder of the famous University of Nālandā (*Cf.* Heras, *The Royal Patrons of the University of Nālandā, J. B. O. R. S.*, XIV, pp. 1–7). In general, the reign of Kumāra Gupta seems to have been as glorious as that of his father, if only the last years of his rule are excepted, when on account of the Hūna invasion and of the victory of the Hūnic Lords over the Gupta army, the fortunes of his family commenced falling, to use the words of the Bhitari inscription of Skanda Gupta.

Strange to say Skanda Gupta, who is referred to in the Saurashtra folk-lore as a king "of weak intellect" (*Cf.* Thomas, *op. et loc. cit.*) is praised to the skies by our author. "Of our progenitors", says he in a panegyrical tone, "whom we ought to have remembered with gratitude, but whom centuries of Musalman (*sic*) oppression, rapine and destruction of records have caused us to forget, the emperor Skandgupta stands in the foremost rank. When the great Magadhan nation forgot its glorious past, its sacred duty of defending the gods and Brāhmanas, women and children, the weak and the helpless and above all the defence of the mother-land, he alone remembered it, tried his best to maintain the glorious record of his ancestors from being tarnished and the rich and fertile plains of the Indus and Ganges from being trampled under the feet of countless hordes of barbarian Huns. He was the last great hero of Maghada who realised that it was his duty to defend the gates of India with the last drop of his life blood. He spent his whole life in the performance of this noble task and at the end of it

sacrificed himself cheerfully in the performance of this sacred duty." (p. 42.) Our idea of Skanda Gupta is just the opposite. Certainly he seems in the beginning of his reign to have defeated the Hūnas and to have "established again the ruined fortunes of (his) lineage", as the Bhitari inscription tells us (Fleet, *Gupta Inscription*, pp. 55–56); but he was defeated by them finally, as the increasing power of Torāmāna evidently shows and our author himself admits (p. 52). He moreover seems to have lost Saurashtra. Banerji blames Kumāra Gupta on account of the "disruption of the Gupta Empire in the time of his second son Puragupta". It would be more logical to blame Pura Gupta himself or at most his immediate predecessor Skanda Gupta. We sincerely believe that this portion of the book gives a totally wrong idea of the period under study.

Equally unfounded seem to be his views about Narasiṁha Gupta. He tells us that his *biruda*, Bālāditya, "caused much misunderstanding among scholars" (p. 54). Evidently he refers to "the statements of the (*sic*) Yuan Chwang about the defeat of the Hūṇa king Mihirakula by a confederacy of kings under the leadership of a king named Balāditya" (pp. 56–57). First of all it must be said that Yuan Chwang or Huien Tsiang does not say a word about the confederacy of kings headed by Balāditya. This alliance is only referred to by Smith (*Early History of India*, p. 337), Havell (*Aryan Rule in India*, p. 175), Pathak (*On the Date of Kalidasa J.B.B.R.A.S.*, XIX, pp. 35–43) and others, who thus want to combine the facts mentioned by the Chinese pilgrim and those disclosed by the Mandasor inscription of Yaśōdharman. Hiuen Tsiang only says that Balāditya defeated Mihirakula (*Cf.* Beal, *Records of Western World*, I, pp. 168–171).

Moreover, the Balāditya spoken of by Hiuen-Tsiang in his account of the Nālandā University is undoubtedly the same king Narasiṁha Gupta of the Gupta coins, where he also receives the same *biruda*, *viz.*, Balāditya. The Chinese pilgrim gives the following relationship among the different kings who favoured that Buddhist University:—

Sakrāditya
|
Buddhagupta-rāja

Tathāgatagupta-rāja
|
Balāditya-rāja
|
Vajra (Beal, *op. cit.*, III, p. 168).

Now the genealogy of the Gupta kings who immediately succeeded Kumāra Gupta I is well known to us through the inscriptions of Skanda Gupta and the Bhitari seal of Kumāra Gupta II. It is as follows:—

Kumāra Gupta I

Skanda Gupta — Pura Gupta

Narasiṁha Gupta

Kumāra Gupta II.

The concordance of these two genealogies is very remarkable. Buddhagupta-rāja is said by Hiuen-Tsiang to be the son of Sakrāditya, just as Skanda Gupta is the son of Kumāra Gupta I. Tathāgatagupta-rāja is not said to be the son, but he appears as the successor of Buddhagupta-rāja, in the account of the Chinese pilgrim ; just as Pura Gupta was the successor but not the son of Skanda Gupta, as he was his brother or half-brother. Balāditya-rāja is styled the son of Tathāgatagupta-rāja, if not in Hiuen Tsiang's travels, at least in his life. (Cf. Hwui Li, *Life of Hiuen-Tsiang*, p. 111); in the same way as Narasiṁha Gupta was the son of Pura Gupta according to the Bhitari seal. Vajra is also said to be the son of Balāditya-rāja, fully agreeing with the Bhitari seal that makes Kumāra Gupta II, the son of Narasiṁha Gupta. There cannot be therefore any reasonable doubt that Narasiṁha Gupta, who had the *biruda* of Balāditya, is the same Balāditya-rāja mentioned by Hiuen Tsiang in his account of Nālandā (Cf. Heras, *The Royal Patrons of the University of Nālandā*, *J. B. O. R. S.*, XIV, pp. 1-4)

Now Hiuen Tsiang mentions also one " Balāditya-rāja, king of Maghada ", in connection with the defeat of the Hūna king Mihirakula. (Beal, *op. cit.*, I, pp. 168-170). Is this Balāditya-rāja different from the king who favoured the Nālandā University with his protection, or is he the same person ? If we consider this question impartially we are led to accept the latter view, for both are given the same name, and the author does not hint at any duality of persons at all ; it is just the opposite. A characteristic note of their personality also discloses the same oneness. The Balāditya-rāja who defeated Mihirakula is said to have " profoundly honoured the law of Buddha " (Beal, *op. cit.*, I, p.168); and the Balāditya-rāja who favoured Nālandā is described as a Buddhist pious devotee. " The King then was affected by a profound faith, he gave up his country and became a recluse " (*Ibid.*, II, p. 169)

But the main objection against the identification of the Balāditya who defeated Mihirakula with Narasiṁha Gupta is, according to Banerji, chronological, (pp. 55-57). From the Sarnath inscription of Kumāra Gupta II we learn that he was already reigning in 473-4 A.D. (*A. S. of. I Report*, 1914-15, II, p. 124). Now Yaśōdharman, who also defeated Mihirakula according to the Mandasor inscription, which

is not dated (Fleet, *Gupta Inscriptions*, p. 148), is said in another dated inscription to be reigning in 532 A. D. (*Ibid.*, p. 152). It seems therefore, impossible that the Hūna king would have been defeated by Yasōdharman round 532 A. D. and by Narasiṁha Gupta Balāditya before 473-4 A. D., *i. e.*, more than 50 years earlier. Such a difficulty increases in the present writer's opinion, for according to him, Mihirakula was first defeated by Yasōdharm and then ultimately by Narasiṁha Gupta Balāditya (Cf. Heras, *The Final Defeat of Mihirakula, I. H. Q.*, III, pp. 8-9).

First of all we must say that Hiuen Tsiang must not be believed as regards the chronology of Balāditya, when he placed this king some centuries before his time (Beal, *op. cit*, p. 167). Many facts, which come to us through tradition only, are evidently wrong in chronology. When figures are transmitted by oral tradition, they may be easily changed and exaggerated. This undoubtedly happened in the present case.

Now as regards the inscriptions of Yaśōdharman, that which records the defeat of Mihirakula is not dated. The dated inscription repays a careful study. First of all this inscription is later than the first, for the second epigraph describes Yaśōdharman "plunged into the army of his enemies, as if into a grove of thornapple-trees, having bent down the reputations of heroes like the tender creepers of trees ", and even refers to the wounds received on the battlefield (Fleet, *op. cit.*, p. 155). All these are allusions to the battles and victories mentioned in the first inscription.

Moreover it is strange that in this second inscription two kings are mentioned, first Yaśōdharman and then Vishṇuvardhana, of whom neither seems to be subject to the other, for both are practically given the same titles. Yaśōdharman is called जनेन्द्रः while Vishṇuvardhana is said to be नराधिपतिः (*Ibid.*, p. 153). They seem to be on an equal footing, the first जयति and the second विजयते. In point of fact Vishṇuvardhana is called *rājādhirāja-pāramēśvara* in the same inscription (vv. 6 and 7), a dignity which cannot be combined with subordination to another king. Yaśōdharman and Vishṇuvardhana therefore seem to be two kings of the same dynasty, the second being the successor of the first, perhaps father and son. If that is so the eulogy of Yaśōdharman in this inscription is posthumous, a thing that cannot be detected in the verb.

Dr. Hœrnle has explained that the King Śilāditya of Mo-la-po (Malwa), who lived 60 years before Hiuen-Tsiang toured India was the son of Yaśōdharman (*J. R. A. S.*, 1903, p. 553); this parentage has been accepted by several scholars (Cf. Mookerji, *Harsha*, pp. 59--60). Even accepting this relationship, it may well be said that Vishṇuvardhana might be the son of Yaśōdharman, for the name

V

Śilāditya seems to be more a mere *biruda* than a real name. The same Hiuen Tsiang always calls Harsha by his *biruda* of Śilāditya. The *Rājataraṅgiṇi* seems to confirm our views when calling the father of Śilāditya, Vikramāditya (Stein, *Rājataraṅgiṇi*, I, pp. 98, v., 330), a name which is also mentioned by Hiuen Tsiang (Beal, *op. cit.*, I, p.106). Thus Hiuen Tsiang and Kalhaṇa give the *birudas* of these two rulers, while the Mandasor inscription records their real names.

Now if the inscription under study is not of the time of Yaśōdharman but of the time of his son Vishṇuvardhana, the year 532–3 A. D. must fall within the reign of the son. In that case there will be no difficulty in stating that the father could defeat the Hūnas about 50 years before, *i.e.*, during the reign of the Gupta King Narasiṁha Gupta Bālāditya.

This King, as Prof. Banerji has noted, had a very short reign. " Puragupta must have died about 468–69 A. D." (p. 54) and his son Kumāra Gupta II was already on the throne in 473–74 A.D., according to the Sarnath inscription mentioned above. Accordingly the reign of Narasiṁha Gupta lasted at most 6 years. It might have been that when ascending the throne " he heard of the cruel persecution and atrocities of Mihirakula". Consequently since he "profoundly honoured the law of Buddha ", " he strictly guarded the frontiers of his kingdom and refused to pay tribute". Meanwhile Mihirakula's army had been routed by Yaśōdharman. When the Hūṇa king heard of the hostile attitude of Bālāditya, he raised "an army to punish his rebellion " (Beal, *op. cit.*, p. 168). The invasion of the Gupta Empire by the Hūna army, the flight of Bālāditya and the casual defeat of Mihirakula may have taken place in less than one year. After the victory and his dealings with Mihirakula, Bālāditya might have commenced the *saṅgharama* which he built at Nālandā (Beal, *op. cit.*, II. p. 173) and the *vihāra* erected also by him at the same place (*Ibid.*, p. 173 ; *E. I*, p. 45, vv. 4–6). After the consecration of the *saṅgharama* he " was affected by a profound faith, he gave up his country and became a recluse " (Beal. *op. cit.*, p. 169). This might be the reason of his short reign, during which all these events may easily be located.

The lectures of Prof. Banerji are sometimes too rhetorical, as if he were forgetting that he is lecturing on a historical subject. For instance the description of the Hūṇa invasion seems to be a little over-done for the sake of oratorical effect. (pp. 47-48). It is also striking that our author does not say anything about the University of Nālandā that was born and grew under the Gupta monarchs.

The best portion of the work is undoubtedly that dealing with architecture and plastic art, in which subjects the late professor was such a great scholar. It is a matter of gratification to see the different

schools of Gupta art finally classified (pp. 175ff.) and the renaissance art of southern India happily excluded from under the denomination of Gupta (p. 182). The collection of plates at the end of the book is extremely interesting and extraordinarily helpful to the reader. One regrets not to find an index at the end of the book. We wish this publication a great success.

H. HERAS, S. J.

मराठ्यांच्या उत्तरेकडील मोहिमा— The Maratha Expeditions in the North, (1720-1740) by Mr. V. M. DIGHE, M. A., Published under the auspices of the Bharat Itihas Samshodhak Mandal, Poona. Pages 80 demy-8vo. Price Re 1.

Mr. Dighe was one of the colleagues chosen by Mr. G. S. Sardesai in his work of selecting for publication important documents from the Peshava-Daftar in the Commissioner's office, Poona, and the brochure under review is the result of the notes which Mr. Dighe then made for his personal use. There are about 30 volumes of original documents published by Mr. Sardesai and it is necessary to use this material for presenting a connected account of the times of Peshawas. Mr. Dighe's effort is one in that direction. For the first time perhaps it is possible for the lay readers to read an account of this glorious period of Maratha history, based on documents. It was in this period that the Marathas appeared to be establishing themselves as the suzerein power in India, but later developments brought about their fall almost as rapidly as their rise and it is one of the most interesting and the instructive study for a historian to discover the seeds of success and failure in the policy of Bajirao I and assess it at its proper value.

Besides giving an authenticated account of the expeditions of Bajirao and his lieutenants in Gujarat, Malva and Bundelkhand, the author of the brochure also discusses their effects on the Emperor's advisers at Delhi, the Marathas in the Deccan and the Nizam at Hyderabad. He admires Bajirao's initiative, courage and foresight and admits that his successes in the North defeated the machinations of his rivals at home and gave new hopes and new ideals to the Marathas. But he says Bajirao can never find a place in the front rank of generals and politicians. He took the fullest advantage of the favourable circumstances about him but he could not mould the circumstances to his ends. Mr. Dighe appears to think that Bajirao was no match in diplomacy to the Nizam and that he made a grave mistake in wasting his energies in striking at Dehli, ignoring the rise of a power-

ful enemy nearer home. Mr. Dighe is probably right in his conclusions, yet one must not forget that the result of the battle of Panipat in 1761 created an unforeseen factor and that factor more than the mistakes of Bajirao decided the fate of the Maratha power in India.

These discussions however come in only incidentally and it is obviously not the object of the writer to express a definite opinion on this question, to do which one must have at one's disposal much more material than is presented in this little book. Mr. Dighe calls this brochure Part I and when his Part II is out it will perhaps enable the historian to obtain a better perspective of the period.

M. R. P.

Gold. A reprint of the Special Number of *The Times* (London), June 20th, 1933. (pp. xii + 238) 6*s*.

The attitude of the average Englishman towards that great institution, *The Times*, is expressed in the question, "I wonder what *The Times* has to say about it". More facetiously perhaps, but equally effectively, it is sometimes crystallised in the outburst, "By George, I'll write to *The Times* about it".

This great paper exercises a very decisive influence over the thought of the people of England. Any opinion voiced by the oracle, any publication issued from its press, carries with it a hall-mark—or shall I say, the Fleet-Street Stamp of truth, respectability and sanity.

Unfortunately, the temptation to yield to popular demand has betrayed *The Times* into an action which will not maintain, let alone enhance, its glory as the purveyor of sound common sense at all times and in all emergencies. Articles which in a supplement satisfy reasonably the requirements of authoritative exposition, fail to come up to the standard of a book that ostensibly enshrines wisdom and intelligence on a particular problem. In other words, while the articles are spendidly written for a free supplement of a daily issue, they fall short of worthiness for collection and publication in book form.

To students of Economics particularly, the book is a disappointment. Only four articles merit any attention, and three of these bear on the same aspect of the problem of gold, its use as national currency for facilitating international trading. And what is worse, neither Prof. Gregory nor Prof. Robbins nor Mr. Withers enlightens us as to the solution of the present impasse. It appears as though each found his cue in the painfully pregnant but almost platitudinous words of Prof.

Robbins (p. 43) ". . . it is much more important to be correct than it is to be original." And so they are courteously correct and disappointingly unprophetic !

It is, of course, obvious that a criticism of individual essays cannot be undertaken, but it may be advisable to state that the first is an admirable one, gathering as it does all the threads that run through the volume. Sir Henry's figures in the next article are illuminating, and though one may not always agree with the conclusions he draws, he summarises, very pointedly, the present position with regard to gold. Says he (p. 19) ". . . the review clearly indicates that there is something radically wrong with the working of the old gold standard. In spite of an adequate indeed an abundant supply of monetary gold (which should have been sufficient to keep the value stable) the standard broke down mainly through the rapid increase in the purchasing power of the metal".

Pray, what is the new gold standard ? And do the figures prove that there has been a sufficiency of monetary gold ? Gold production has not only maintained its former rate of annual increase but has responded generously to the invitation of higher prices. But the present economic disturbance is caused by an even faster increase in the habit of saving in the sense of hoarding. The world seems to have forgotten the spendthrift's excuse : ' the coin is made circular so that it may circulate !' And the Bankers have conveniently forgotten the rules of the game — to allow the influx of gold its natural reactions.

The gold standard is not responsible for the over-valuation of the metal. It is the absence of it and the consequent desire to possess ample reserves for its re-introduction that has led to a mad and senseless and pathetic scramble for gold. One sees in it the same fatuity as in the craze for artificially depreciated currencies. Both bear within themselves the seeds of self-destruction. Gold is not only and not so much a store of value as a medium for international settlement ; its primary function in normal equilibrium is to lubricate the wheels of international exchange. When it degenerates into a mere hoard, a store of wealth, it fails to act as a standard. Strangely enough, Sir Henry's economic acumen leads him to the same analysis.

The world has so long been treated to lamentations on the hoarding tendencies of the East, (that step-child of Fortune !) that it may have been useful, and certainly would be in keeping with the desire to bestow " shocks ", on the old, particularly, to stress the disgorging of gold that has taken place. The psychologists, who have so long believed that human nature is the same all over the world, will rejoice in the phenomenon of the Westerner displaying the same

barbaric greed and subscribing to the same superstition which politicians and economists ascribed solely to the Easterner.

As ever an ingenious and almost ingenuous piece of specious reasoning as found in text books on logic is given us by Mr. G. St. J. Orde Browne who is hard put to it to justify unequal wages for equal work. Says he (p. 153), "This standard, naturally, results in a measure of colour distinction. Trade union rules uphold this and friction sometimes arises in consequence. These however should not be condemned without consideration, since there is, in addition to any question of colour, the problem of the standard of living. The native has, as a rule, far fewer requirements and he lives in much more primitive conditions; the European therefore resents any attempts to displace him by a lower paid worker whose employment would lead to a general debasement of the whole mode of life of the mining community". Here, we have a classic instance of those many what-can-be-done-about-it situations, of the helplessness so characteristic of a hard-up unsympathetic government or a pitilessly self-complacent world. Further comment is hardly necessary.

The article on the Bank of England is a brilliant piece of work, as beautiful as the style and expressive of the thought and tradition as the wonderful edifice it describes, and the essay by Mr. Watson, though hardly a study in sociology, is in vivid contrast to the mythically heroic tales of the "Pioneers of the Golden West". Certainly, it gives one those "occasional shocks of surprise" which the first article leads one to await with delightful suspense.

This is one of the pleasant shocks, for disillusionment is otherwise hardly pleasurable. The other is the refreshing absence of Mr. Keynes among the contributors: too long have we been subjected to the sneers and devastating criticisms of this great economist. A third is the extremely engrossing article on "Revised Trade Cycles Chart" by Mr. Donald K. Kitchin, who draws rather unorthodox conclusions from statistics, so carefully compiled by his father, Mr. Joseph Kitchin whose untimely death cut short his valuable researches. This "represents the quintessence of his work in economic statistics" and is the only article which merits the serious consideration of Economists, providing excellent, if at first slightly heavy, food for thought.

But, for an error on p. 77 where the ratio should be, not 10 to 1, but 100 to 1, (obviously a printer's error), the book is beautifully brought out, as is only to be expected from *The Times*. Very numerous plates are incorporated and the print is excellent.

If for no other reason, at least for the enterprise and the novelty, the publication is to be commended and many a reader will pass a happy two hours in its company.

JOS. E. CASTELLINO

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Journal

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VOL. II · MARCH 1934 PART V

THE BIONOMICS, MORPHOLOGY, AND METAMORPHOSIS OF MELIPONA IRRIDIPENNIS

By

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Observations on a hive.

In February 1924, I happened to find a hive of *Melipona irridipennis* in a crevice on the wall of my house at Coimbatore. As no account of this bee was available from India, I proposed to make a study of it. As long as the hive was situated inside the wall, observation was impossible, and so I very much desired to have the bees transferred to a better situation. As they build irregular combs, transferring them to an ordinary hive was out of the question. It occurred to me to try whether the bees would take to a vessel of 12″ diameter if it was fixed to the wall in such a way as to bring the entrance of the hive inside the vessel. An earthen vessel was fixed on the wall and a small hole about ¼″ in diameter was made on the lower side of the vessel to serve as an entrance.

The bees were a little alarmed at this sudden alteration of the surroundings, but in the course of two or three days they made themselves quite familiar with the additional space and were making use of the new entrance. But it took about eight weeks for them to be convinced of the reliability the new hive offered to them. By cutting off a piece 3″ x 3″ from the earthen vessel on one side and replacing it with black paper pasted on the outside, a crude but very useful doorway for making observations was made. An electric torch light

had to be used for illuminating the hive, though it caused a certain amount of disturbance among the inhabitants.

The first step in the conversion of the vessel into a hive was the construction of a tubular entrance with the sticky material made of wax and earth known as "cerumen." This was accomplished by the third day. Three or four workers were invariably posted at this entrance as sentries. Nothing more was done till the next April. During the course of my usual examinations one day I noticed that a certain amount of wax was fixed up in the small crevices left between the pot and the wall. This work was done with such speed that during the course of three days the bees had begun to build the foundation of pollen combs. During the course of the succeeding week about two dozen pollen cells were constructed, a good number of which were also filled. Obviously the favourable Summer season had much to do with this enormous output of work. The next step was the construction of honey cells which were erected on the roof, separate from the pollen cells. The appearance of the honey cells was so deceptive, as not to attract my attention until their number grew up to about half a dozen. Soon after, the foundation of the brood cells was also made out in the right half of the vessel. In the course of a few days a huge cluster of beautiful cells was constructed and in some of them eggs were laid. I could not observe the queen at work as she would disappear from the surface of the brood cells as soon as I would open the hive. By the end of April a well established colony was inhabiting the new hive. New pollen, brood and honey cells were added one after another and the first set of workers hatched out by the last week of May. New individuals were added to the colony every day and by July the colony was enormously strong and the whole hive was filled up with brood, honey and pollen cells. Every time the paper door was closed after an inspection the workers glued it with wax.

Towards the close of July the monsoon broke and it took an enormous toll of the colony. As the number of workers was reduced the food supply was not replenished at the same rate it was used up. After some time therefore there was a lull in the production of new brood cells. But mention should be made of the few workers hatching out every day. Amongst the existing brood cells of that time, there were a few larger than the ordinary ones and one of them was particularly large.

On the 17th of August, one of these big cells opened and the others followed the next day. It was not possible to recognize the newly hatched individuals from the larger cells amongst the large number of workers. On the 21st, while examining a few bees lying dead on the floor, I found to my surprise that there were two drones

amongst them. Probably the workers had killed and thrown out the newly hatched drones from the larger cells. The largest cell of the lot was possibly a queen cell and the queen was also presumably killed. By the second week of September, as the monsoon stopped, a revival of activities began and the breeding went on as vigorously as ever. The honey and the pollen stores which were almost used up during the bad season were soon replenished. But occasional spells of rain seriously hampered the continued progress of work in the colony.

Then came the Winter months, December, January and February. Though Winter is not severe at Coimbatore, there was a slowing down of the activities of the bees. The glorious Summer of 1925, with its beautiful blossoms everywhere, followed. The little artisans made the best use of the season and one could hear so well the hum of the hive. A long stream of workers was going in to unload their burden of pollen and honey. On the 28th of June I removed the the vessel from the wall and, without disturbing the brood cells, cut out the honey combs, leaving only a few. These combs yielded about four ounces of honey, a quantity double that of an ordinary hive from inside a decayed tree or a wall. The young workers greedily made a feast of the honey spilled while removing the combs. The wax of the combs was restored to the hive and the vessel was fixed in its original place. The hive was not disturbed for a week, and when I opened it next, I found that everything was in order. The honey which was left in the hive was either used up or devoured by the workers. The wax that was returned to the hive was converted into thin sheets and spread inside the hive.

On August 18th 1926, I removed the whole hive as I was leaving Coimbatore and, on examination, found that the crevice inside the wall was still retained as part of the hive with brood, pollen and honey cells. Though almost two months had elapsed since my removal of the honey combs, not a single honey cell was constructed in place of those removed, but among the pollen combs were found twelve honey cells. There was only one queen, which was hiding among the brood cells inside the crevice on the wall and there was a drone, only a few hours old. It is concluded from the above observations on the hive that the honey season is from March to June and that this season is also the season for prolific breeding. This further supports my observations in South and Western India on *Apis indica* that Summer is the only honey season. Supplies of honey from the hills also lead to the same conclusion.

External morphology of the adult.

See the Fauna of British India, Hymenoptra Vol. I., p. 563, for a detailed account of specific characters. The following features of external morphology may however be of interest.

The worker is a small dark creature of 3-4mm. in length. The queen is similar to the worker in its morphology but larger in size and paler in colour. The drone is but slightly larger than the worker and so is difficult to be distinguished from the latter. He differs from the queen and the worker in having twelve segments to the flagellum of the antenna, while the latter have only eleven.

The head is round, the antenna is typically Hymenopteran with a scape and flagellum. The flagellum is provided with numerous sub-circular or oval pits with hairs which are regarded as sensory in function. The maxillae and the labium are folded on themselves, the former at the junction of the cardo and the stipes, and the latter at the base of the ligula. The folded organ fits into a groove on the ventral side of the head when at rest. The folding of the maxillae and the labium afford full free play to the mandibles which lie above. The maxillae bear rudimentary 2-jointed palps. The lacinia are placed in close approximation to the basal portion of the stipes which is a well developed structure. The labial palpi are five jointed. (Vide Fig. VI).

The hind tibia is enlarged to function as the corbicula or pollen basket. The usual two kinds of hairs, simple and branched, occur all over the body. The branched ones are of use in collecting pollen. The hind wings interlock with the fore wings by means of five hamuli. (Vide Figs. II & III).

A functional sting is absent, but the parts are present in vestiges, as shown by von Jhering, and they are more pronounced in the queen than in the worker. The 7th abdominal segment is the last visible one and all the segments behind it are telescoped into it. The 7th sternum is bifid posteriorly and if it is turned over, the concealed segments are revealed. On either side a pair of characteristic plates bearing spiracles is seen inside the 7th segment. These plates have been shown in the honey bee to be part of the 8th tergum by Zander. Mesially there is a pair of plates which corresponds to the "oblong plates" of the honey bee bearing distinct palps. On the inner faces of these are present elongated structures representing the sheath of the honey bee sting or the inner ovipositor lobes of other insects. The anterior ovipositor lobes or the lancets of the honey bee sting, are also present as vestigial structures. (Vide Fig. VIII).

In the male the 9th segment bears a median aedeagus on either side of which is a well chitinized paramere. The gonocoxite is present and shows a basal cardo and a distal stipes regions. Melipona differs from Apis in the fact that parameres are absent in the latter. (Vide Fig. VII).

Life-history and bionomics.

Swarms are given off from the older hives usually in August or September in Coimbatore. This corresponds to what is obtainable in *Apis indica.* In other parts of India this may depend on the incidence of the monsoon. I have never noticed a new colony settling down, but I happened to observe one soon after it had occupied a small crevice in a wall. There were about a hundred workers, which were coming out and depositing small pieces of mortar at some short distance from the hive.

The brood combs are constructed on pegs of wax fixed to the wall, and by the addition of new pegs and new cells an elaborate maze of brood combs is established. (Vide Fig. I). The wax is of a dark brown colour and very soft to the touch. A brood cell is roughly 3½ x 2 mm. Each cell is half filled with a mixture of honey and pollen, and when a thin film is formed on the surface of this viscid mass, an egg is laid in a perpendicular position and the cell is closed. The egg and the larva do not sink in the liquid and thus keep in touch with the air enclosed in the cell. (Vide Fig. IV). The egg is about 1 mm. in length and ⅓ mm. across. It takes four or five days to hatch out. The newly hatched larva is 2 mm. long and is a delicate, almost transparent, creature. The full grown larva is 5 mm. long and is rather stout in appearance. The feeding larva is transparent yellowish brown in colour due to the food in the alimentary canal, while the pupating larva and the pupa are opaque white in colour. Before pupation it spins a white cocoon and the adult emerges by piercing this cocoon, which by that time has adhered to the waxy cell. It takes three to three and a half weeks from the egg to the adult stage. The brood cells show slight variation in size and the newly hatched workers also exhibit a corresponding variation in size. The queen cell is the largest and is therefore easily recognized. The drone cell is slightly larger than that of the worker and is difficult to distinguish from the larger worker cells. In a hive apparently at a time never more than two queen cells are constructed, but there may be as many as ten drone cells.

The pollen and honey cells measure about 7 or 8 mm. in length and 3½ to 4 mm. in thickness. They are constructed in rows fixed to the wall without any intervening pegs. (Vide Fig. I). The pollen store varies from light bright yellow to dark brown in colour, the bees chiefly visiting plants with abundance of pollen, such as the Graminaceae. The honey is of pale yellow colour but a tinge of pollen gives it a beautiful red colour and it is almost impossible to collect this honey without some admixture of pollen, as honey and pollen cells are constructed together. The honey has a sweet slightly sour taste. These

bees are exceedingly tame and freely enter the flower shops. They also visit the sweetmeat shops to collect the sugary juice present in some kind of sweetmeats.

The entrance to the hive is a narrow circular hole, the wall of which is made of "cerumen" which projects about half an inch to the outside. (Vide Fig. I). A few workers guard the entrance, their number varying according to the circumference of the entrance. The tubular entrance does not directly lead to the hive, but terminates in a round cavity from which there are two inlets, one to the broad combs and the other to the honey and pollen combs. This round about entry to the hive may serve two purposes, the prevention of direct light which these insects abhor always and the sudden invasion by any enemy. There is a network of paths under the brood cells to facilitate easy access to any part within the hive. This is very necessary as the brood cells from which adults have emerged are destroyed at once and new ones constructed. Very soft wax is used for making the cells but harder wax is used to close any crevice or to strengthen any weak spot in the hive. Any wax found outside is assiduously collected and deposited in some part of the hive, without it ever interfering in the normal working of the hive.

I have not observed any parasites or predators of these bees, but a species of Megachile sometimes visits the hive and snatches off some wax from the entrance.

The larval anatomy.

The mature larva is rather stout and lies bent on itself in the cell. The external cuticle is very thin. The narrow head segment is followed by 13 segments.

The central nervous system.—The central nervous system consists of supra-oesophageal ganglia or brain, situated in the posterior region of the head, and a double ventral nerve cord of 11 distinct ganglia situated in the first eleven segments of the body. The last two segments have no ganglia but are innervated by nerves from the eleventh. In section a ganglion exhibits an internal medullary region and an external region of ganglion cells and the whole is covered by a thin enveloping membrane. (Vide Fig. IX).

The digestive system.—The buccal cavity opens into a short pharynx which is connected to the midgut by a narrow oesophagus. The hindgut lies bent on itself below the midgut, its anterior end being in contact with the posterior end of the midgut. There are four thick malpighian tubules which take their origin from the hindgut at its junction with the midgut.

The silk glands.—There is a pair of silk glands situated ventral to and on either side of the alimentary canal, extending posteriorly to

the 8th abdominal segment. The two glands unite in the region of the suboesophageal ganglia and passing below these open on the lower lip. The duct of the glands opens between two dorso-ventrally flattened spiny processes which appear like a pair of forceps in longitudinal sections. The gland shows a layer of large epithelial cells and a central canal running through the whole length. (Vide Fig. IX).

The respiratory system.—There are ten pairs of spiracles, two thoracic on the meso- and meta-thorax, and eight abdominal on the first eight abdominal segments. The spiracular opening leads to an atrium which narrows at its proximal end and opens into a short trachea. The short trachea takes a ventral transverse course and opens into a longitudinal main trunk. The two main trunks are connected anteriorily and posteriorly by transverse trunks. At the junction of the spiracular tracheal branch and the main trunk, smaller tracheal branches are given off.

The vascular system.—The hemocoele is mostly occupied by the fat body. The fat body consists of round or hexagonal cells very closely packed together. Each cell has a central nucleus and a clear cytoplasm showing a number of vacuoles. Imbedded in the fat body are a few oenocytes which in sections appear in all sorts of shapes varying from triangular to circular.

The gonads.—Lying dorsally in the worker is a pair of ovaries in the 5th abdominal segment. Anteriorly the enveloping layer of the ovaries is continued as a narrow strand which extends upto the 4th abdominal segment. The male gonads have not been studied.

Metamorphosis.

1. *The imaginal buds.*—In the mature larva there are in the head imaginal buds representing the antennæ, compound eyes, mandibles, maxillae and labium. In the thorax there are three pairs representing the legs, and two pairs foreshadowing the wings. There are also thickenings of the hypodermis in segments 8 and 9 representing the gonapophyses in the worker larva. The hypodermis of segment 7 also shows a slight thickening on the ventral side. (Vide Fig. IX).

2. *The nervous system.*—It has already been stated that in the mature larva there are 11 ganglia on the ventral nerve cord, 3 in the thoracic and 8 in the first eight abdominal segments. According to Nelson there are 11 ganglia in the abdomen in the embryo of the honey bee in the early stages and in the later stages the 9th, 10th and 11th unite and come to lie in the 9th abdominal segment. During the early larval life the terminal ganglion unites with the preceding one and lies in segment 8. Thus the larval nervous system is derived. The number of ganglia in the mature Melipona larva agrees with that

of the honey bee and presumably therefore the last ganglion in the 8th abdominal segment is a compound one representing segments 8, 9, 10, and 11. During the early stages of metamorphosis, which is soon after defaecation, the 1st abdominal ganglion moves forward and fuses with the metathoracic one. During a later stage when the limbs and the mouth-parts are about to unfold from the imaginal buds, the 2nd abdominal ganglion is seen about to fuse with the one in front. At this stage the penultimate abdominal ganglion, the 7th, fuses with the preceding one and comes to lie in segment 6. During the pupal stage, the compound ganglion of the metathorax and the mesothoracic ganglion fuse together. Thus in the adult there are 2 thoracic and 5 abdominal ganglia. The fusion of the ganglia takes place by the gradual absorption of the intervening cord. The 1st thoracic ganglion is situated in the prothorax and innervates that segment. The 2nd thoracic ganglion is situated between the meso- and meta-thorax and innervates these two segments, and also the 1st and 2nd abdominal segments. The first free abdominal ganglion (i.e. the true 3rd) though situated in the 2nd abdominal segment, properly belongs to the 3rd abdominal segment and therefore innervates that segment. The 2nd and 3rd abdominal ganglia situated in abdominal segments 3 and 4 respectively innervate segments 4 and 5. The 4th abdominal ganglion is formed of the true 6th and 7th and is situated in segment 6 and innervates segment 6 and 7. The last ganglion is situated in segment 7 and innervates segments 8, 9 and 10. Snodgrass in the "Anatomy and Physiology of the Honey Bee" states on p. 293 that in the adult honey bee the penultimate ganglion is formed by the fusion of the true 6th and 7th ganglia. This is true of Melipona as well as *Apis indica.* But he fails to reconcile the adult anatomy with the changes taking place during metamorphosis. According to him (vide p. 273) the penultimate ganglion of the adult bee lies in the 6th segment of the abdomen and innervates that segment. Specimens of *Apis dorsata* and *indica* were dissected to see if the above statement was correct. It was found that the 6th abdominal ganglion gave rise to two pairs of nerves, as might be expected from its composite nature, of which one pair innervated the 6th segment and the posterior pair the 7th segment. (vide Figs IX and X). Snodgrass' description on p. 273 is therefore obviously incorrect. His figure however is correct.

3. *The digestive system.*—At the beginning of pupation the posterior region of the midgut, where it is pressed against the hindgut, breaks down and the faecal matter stored up in the midgut is passed to the outside. The malpighian tubules which in the larva do not possess any opening at all, also come to open and empty their contents into the gut. As a natural consequence the gut and the malpighian

tubules shrink. Histolysis of the epithelium of the gut soon follows and this results in its eventual absorption. A layer of new epithelium, which was already growing around the old one, takes its place. The fore- and hind-guts also undergo the same process of degeneration and regeneration. The foregut soon after widens out and its epithelium becomes developed into a layer of deep columnar cells. Where the foregut meets the midgut the former enlarges into a structure which gradually develops into the so-called " honey stomach ". The malpighian tubules of the larva degenerate and disappear entirely. With the degeneration of the larval tubules, imaginal tubules are budded off from the regeneration area of the hindgut. The hindgut which was a bent tube lying beneath the midgut in the larva, becomes a straight tube during the early stages of metamorphosis. The anus which was situated at the posterior extremity of the long axis of the body in the larva, has now come to lie on the ventral side. During the late pupal life the hindgut widens out at its posterior region and this ultimately develops the rectum with its elaborate system of glands.

4. *The silk glands.*—The silk glands undergo complete histolysis and disappear entirely.

5. *The fat body.*—The larval fat body cells show a central nucleus and a vacuolated cytoplasm when stained with Mallory's Triple Stain. But the fat body of the pupating larva when stained with the same stain shows a number of globular bodies in the cytoplasm, some stained red, some reddish blue and others light blue. These bodies according to Berlese and others, are albuminoids occurring in different stages of elaboration. The fat body cells soon lose their cell membrane and these globules are thrown out into the blood. Sections of pupæ show that most of the fat has been used up during metamorphosis, there being only a few cells and globular bodies left floating in the blood. The oenocytes embedded in the fat body are liberated when the latter breaks up. They assume more or less a globular form and eventually seem to undergo degeneration. There is considerable difference of opinion regarding the fate of the larval oenocytes. According to Koschevnikov (1900) and Weisenberg (1907) the imaginal oenocytes arise from the hypodermis during the pupal stage, most of the larval ones degenerating entirely. Perez (1903) however states that Koschevnikov's observation is erroneous. In Melipona a large number of small oenocytes are seen near the hypodermis during the early pupal stage, and these differ considerably in size and staining qualities from the larval oenocytes. There is every reason to suppose that these are the newly formed cells which persist in the adult as imaginal oenocytes. Thus my observations support those of Koschevnikov.

Mention should be made of another set of cells which make their

appearance during the pupal stage. They are completely absent in the larva and they make their appearance during the prepupal period, and are limited to the abdominal region. These modified fat cells are characterized by their large size, being visible to the naked eye as dark bodies amidst the fat cody in the pupating larva. There is a central nucleus with a granular cytoplasm and a thick cell membrane. The cytoplasm does not absorb any stain.

Many workers seem to have noted these cells but apparently have regarded them as oenocytes. Karawaiew (1898) describes in Lasius a set of large phagocytes and his description of these cells fits in very well with the cells described above. I have not been able to observe any phagocytic tendency in these cells which I have described. They show certain inclusions in the cytoplasm which appear to be excretory products. In the adult they become crowded to the posterior region of the abdomen and finally seem to disintegrate. Their cytoplasm shows also a general resemblance to that of nephrocytes, and I have therefore preferred to call them pronephrocytes. (Vide Fig. IX).

6. *The female efferent genital system.*—It has been said above that the oviducts terminate on the ventral side of the 7th abdominal segment in the larva. During the early stages of metamorphosis three ventral hypodermal thickenings which ultimately result in three invaginations develop. The first of these is from the anterior region of segment 8, and is the vaginal invagination. Such an invagination has been noted by Nel in Locustana in the same situation. Morphologically therefore it is homologous to the invagination in Orthoptera and Homoptera. This invagination as it grows forward becomes dorso-ventrally flattened anteriorly. Later on its dorsal and ventral walls meet and fuse along the median line at the anterior half. This results in the formation of two ducts at that region. These two ducts meet the oviducts of their respective sides and during the later pupal stage fuse with them. Thus the female efferent system is established.

Meanwhile the second and third invaginations also elongate, the latter showing more pronounced growth than the former. The former takes its origin from the median ventral side of the 8th segment behind the rudiments of the anterior ovipositor lobes. At its posterior extremity it opens into a groove which later on extends anteriorly and posteriorly till it meets the other two invaginations. The second invagination is that of the spermatheca. As pupation proceeds the hypodermis intervening between the first and second invaginations shrink in such a way as to approximate the two invaginations. At the same time the ventral wall of the vaginal lip grows posteriorly thereby shifting the vaginal opening backwards. As a result of these changes the spermathecal invagination not only becomes confluent with the vagina

but comes to lie on the dorsal side of the vagina. This is the condition in which it is found in the adult.

The third invagination takes its origin between the rudiments of the ovipositor lobes and elongates anteriorly until it occupies an oblique position in the body cavity. A short distance from its opening it widens out into a sac, though at the anteriormost region the lumen is narrow. This is the rudiment of the acid gland. The wider region develops into the reservoir of the gland. (Vide Fig. XI). In the worker the efferent system occurs in a less developed condition than in the queen.

Snodgrass figures and describes the vagina as opening at the anterior region of the 8th segment and anterior to the anterior ovipositor lobes in the pupa. Seurat also places the vaginal opening at the anterior region of the 8th segment. Tiegs places it further back between the first and second pair of appendages, *i.e.*, between segments 8 and 9. In the adult Hymenoptera the vagina opens in the situation described by Tiegs. The above described mode of formation of the oviduct and the consequent shifting of the vaginal opening to the 8th segment recalls the process which I have described in the case of Homoptera in an earlier paper (Q.J.M.S., 1929). In Homoptera the original vaginal opening which is behind the 7th corresponds to the vaginal opening during the early pupal stage in Melipona. But none of these workers has studied the development of the common oviduct in detail and thus they failed to notice the shifting or carrying back the female opening behind the 8th. The spermatheca is regarded by these workers as an outgrowth of the vaginal invagination; in Melipona it is a distinct invagination in itself and opens independently of the vagina as noted by Zander in Apis, though subsequently it becomes fused with the vagina. The development of the spermatheca is exactly on the same lines as in Diptera, noted by Christophers and Baraund, and in Orthoptera, noted by Nel.

One significant fact is that the sting glands are present though the sting itself is vestigial and non-functional. This compels us to assume that these glands are functionally female accessory glands. In Apidae the secretion from these glands containing formic acid prevents putrefaction and growth of moulds in honey and pollen store. Possibly similar use is found for them in Melipona. The ovipositor lobes are not properly developed occurring only as rudimentary structures. Tiegs regarded the genitalia of Nansonia female as having developed out of segments 8, 9, and 10, and states in that connection that such a development is in accordance with what Dewitz found in Locustidae. Obviously Tiegs has misinterpreted Dewitz who stated that the inner ovipositor lobes appear as processes from lateral lobes of the 9th segment.

Summary and conclusions.

1. A general account of the life-history and habits of *Melipona irridipennis* is given. It has been observed contrary to the general conception that hot months from March to July form the period of great activity as was noted in the case of *Apis indica* and *dorsata* in another connection.

2. The general morphology of the worker is given. Larval anatomy and metamorphosis has also been worked out. Special features are : (a) A few fat cells become modified as excretory cells during metamorphosis (pronephrocytes) ; (b) The adult oenocytes are formed from the hypodermis of the pupa ; (c) The larval nerve cord with three ganglia in the thorax and eight in the abdomen becomes modified into a cord with two ganglia in the thorax and five in the abdomen when the adult condition is reached. The composite nature of the penultimate abdominal ganglion is established on anatomical and developmental grounds ; (d) The formation of the female efferent system has also been studied, and it has been found that it takes place on the same lines as in Homoptera (George, and Metcalfe), and Orthoptera (Nel). The accessory glands (the poison glands) are present though the sting has become non-functional. It has been inferred therefrom that these glands are ancient structures of physiological importance in connection with the reproductive habits of the animal and their function as poison glands is a secondary modification. Such glands arising from the 9th abdominal segment are present in Homoptera and Orthoptera, etc.

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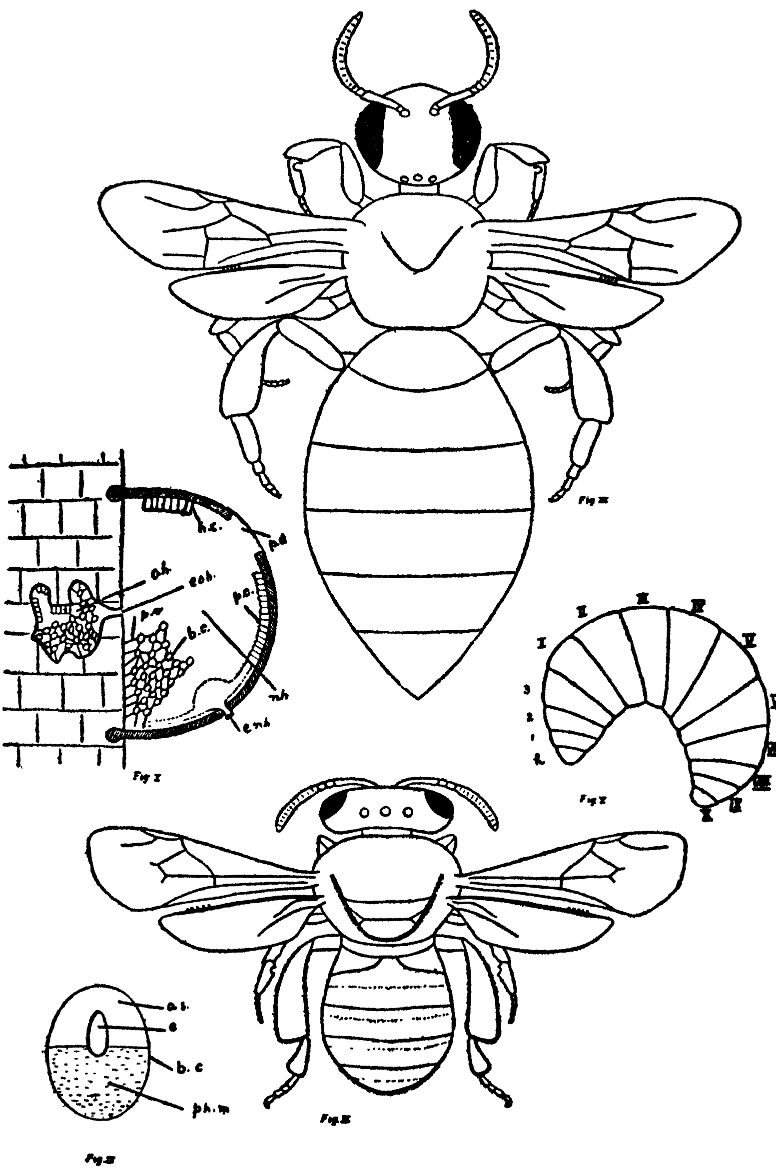


EXPLANATION OF DRAWINGS.

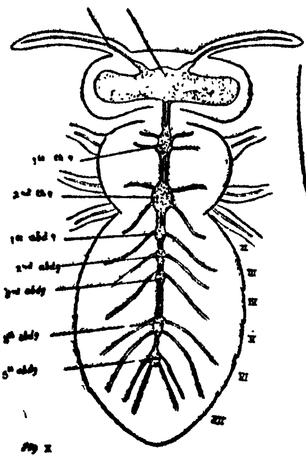
Fig. I. A diagrammatic section of the hive of *Melipona irridipennis* kept under observation.

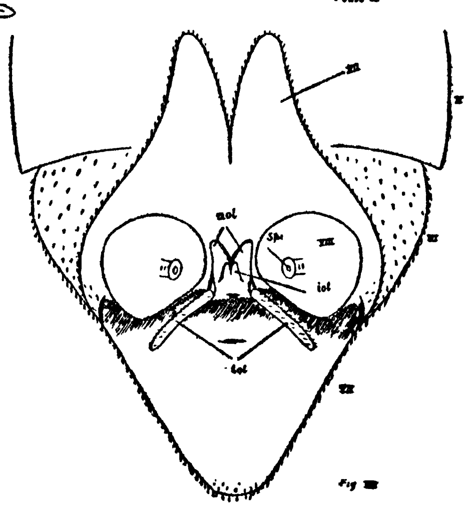
Fig. II. The worker of *Melipona irridipennis.*

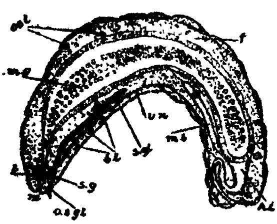
Fig. III. The queen do.

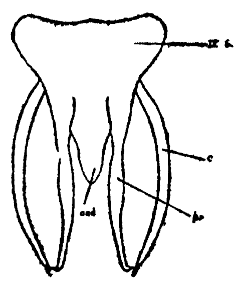
Fig. IV. Egg in situ in a cell do.

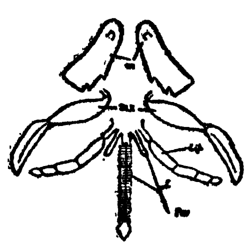
Fig. V. The larva do.











EXPLANATION OF DRAWINGS.

Fig. VI. The mouthparts of the worker, *Melipona irridipennis.*
Fig. VII. The genitalia of the drone, do.
Fig. VIII. The genitalia of the queen, do.
Fig. IX. A vertical longitudinal section of a mature larva, do. (diagrammatic).

Fig. X. The nervous system of the adult, *Melipona irridipennis.* (semi-diagrammatic).

Fig. XI. A vertical longitudinal section of the hind region of the abdomen of a pre-pupa, do.

LETTERINGS.

1. 2. 3.	Thoracic segments.	l.p.	Labial palp.
I. to X.	Abdominal segments.	m.	Mouth.
a.	Anus.	m.d.	Mandible.
abd. g. 1st-5th.	1st to 5th Abdominal ganglia.	m.g.	Mid-gut.
aed.	Aedeagus.	m.l.	Malpighian tubules of the larva.
a.g.	Acid gland.	mx.	Maxilla.
a.n.	Antennary nerve.	mx.p.	Maxillary palp.
a.o.l.	Anterior ovipositor lobe.	n.h.	New hive.
a.s.	Air space in the cell.	o.d.	Oviduct.
b.	Brain.	o.h.	Original hive on the wall.
b.c.	Brood cell.	oc.l.	Oenocytes of the larva.
c.	Gono-coxite of the male.	o.s.l.	Opening of the silk gland.
e.	Egg.	p.c.	Pollen cells.
e.n.h.	Entrance to the new hive.	p.d.	Paper door.
e.o.h.	Entrance to the old hive.	p.h.m.	Pollen honey mixture.
f.	Fat body.	p.v.	Pegs of wax to which brood cells are attached.
h.	Head.	s.g.	Sub-oesophageal ganglion.
h.c.	Honey cells.	s.gl.	Silk gland.
h.i.	Hind intestine.	spi.	Spiracle.
i.o.l.	Inner ovipositor lobes.	sp.	Spermatheca.
l.	Ligula.	th.g.1st.	1st thoracic ganglion.
l.o.l.	Lateral ovipositor lobes.	th.g.2nd.	2nd thoracic ganglion.
		v.	Vaginal invagination.
		v.n.	Ventral nerve cord.

DEVELOPMENT OF THE TROUT SCALE

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(*With 4 plates*)

Introduction.

The following paper contains an account of an investigation on the development of the Teleostean scale, chiefly that of the Trout, *Salmo fario* and *Salmo irrideus.* The Teleostean scale has been studied by a large number of investigators, [Leydig (1851), Baudelot (1873), Hofer (1889), Klaatsch (1890), Ussow (1897), Tims (1902), and more recently by Hase (1912), and by Paget (1920)].

Klaatsch's (1890) account of the development of the Teleostean scale, although supplemented by the work of others, has remained the standard authority. In the interpretation of the several details there is, however, an entire lack of agreement. The accounts of different investigators vary to an extraordinary extent in the matter of detail; this is largely due to technical methods of investigation, e. g., the scale being an extremely hard structure there is great difficulty in cutting it into thin sections.

The literature on the subject has been reviewed very thoroughly by Stuart (1904) and Paget (1920). The latter author in his review presents points from the work of other investigators where lack of agreement exists; I shall go into these details later, and, while discussing the more important points, shall refer to the work of the several authors.

For the suggestion of this problem and for much valuable advice I am greatly indebted to Mr. J. Gray.

Methods.

(a) General fixing and staining methods.

The material was fixed in at least four fixing reagents, viz. Bles' fluid, corrosive sublimate, Fleming without acetic, and Bouin's fluid. I found Bles' fixative very satisfactory, giving good fixations.

Great difficulty was experienced before satisfactory preparations were secured; it is by no means easy to obtain preparations in which the cell-boundaries and cell-layers are sharply differentiated. Several stains were employed to bring into evidence the intercellular network,

and were abandoned as unsatisfactory, for the scale-layers proved unusually difficult objects for cytological study.

Of the methods employed, the silver impregnation gave the best results; the only difficulty being that the nuclei in such preparations did not take up the stain; the cell-boundaries are, however, shown with special distinctness, which made it possible to distinguish between the different cell-layers.

(b) Special method.

The scales to be impregnated must be fresh, that is, such as have not been treated with any reagent. It is only fresh scales which will impregnate.

The fresh scales are first washed in distilled water containing a trace of sodium sulphate (0·75%) for 2 or 3 minutes. They are then transferred to silver nitrate 0·2% solution for 5 minutes; after this they are again washed in distilled water. After this washing they are developed in any clean developer, (e. g., Amidol 0·2% in 2% sodium sulphate diluted with water 5 or 6 times, from 2 to 3 minutes).

After a final washing in distilled water, the scales are mounted in glycerine.

Material.

The numerous specimens of Trout used during the course of the investigation were obtained entirely from Nailsworth in Gloucestershire. These were sent alive to Cambridge.

Description of Scale Development.

(a) Early appearance.

The first stages of scale development take place in fish larvae of about 3 cms. in length and when the fish is about 75 days old. The trout material obtained from Nailsworth proved remarkable in that the fish, growing under practically identical conditions in tanks, showed great variation in size. It was found that some fish grew much more rapidly than others and fish of the same age varied markedly in size. The first scales to appear were those of the lateral line. Certain relatively large fish occasionally showed no trace of scales. Such individuals were, however, extremely rare. Attention has been very often drawn to the close relationship between the scales and the age of the fish; the study of the scale development in the trout shows that the scales do not appear uniformly over the whole body, and the scales from different regions show variation in the number and even width of annuli. It may be mentioned that, in the early stages, in between the fully developed scales, one also comes across smaller scales with fewer lines of growth. These small scales are mentioned by Klaatsch. This irregularity is very marked in some of the fish, but as growth proceeds one rarely meets with it.

The first indications of the formation of the scale are seen in the outer part of the dermis, in which appear a series of cell aggregations; an early sign of development is the frequency of mitotic and amitotic figures in the region below the basement membrane of the epidermis. This continued activity results in the production of hillocks as seen in Fig. 1. In transverse sections, several layers of cells are seen at this stage. The cells in a cluster have large nuclei and each has a deeply stainable protoplasmic body. Each of these clusters extend laterally and represent flattened papillae. At this stage the dermis differentiates into two layers, an outer spongy and an inner fibrous layer; these two regions merge into each other, there being no distinct boundaries.

The first indication of the appearance of the scale itself is a thin sheet of a highly refractive substance; the scale at this stage is symmetrically enveloped by the dermal cells which on their outer side appear several layers deep (Fig. 8). These cells, to which Klaatsch has given the name of "*scleroblasts*", separate the scale completely from the epidermis, which never takes any part in the development of the scale; very often the scale lies in the epidermal region of the body; this occurs as a result of oblique cutting of sections. While the above changes are taking place, Hofer (1889) and Hase (1907) believe that the basal epidermal cells undergo a remarkable alteration. According to these authors, in the trout the basal layer of the epidermal cells, which lie immediately over the developing scale, become modified to form an enamel membrane, though the structure never becomes functional. Later they reassume their original form, losing this special character. Hofer attaches to this fact considerable phylogenetic interest because in the development of the Ganoids and the Placoids the larger portion of the spine is epidermal. In the Teleostean scale, the scale takes its origin in the dermis, and throughout life remains a dermal structure. Hofer and Hase see in this fact an indication of ancestral condition, According to Paget the epidermal cells lying immediately over the young scale become cylindrical although the change is not universal. I have gone through all the preparations with special attention to this point, but in no way have I been able to find structures corresponding to those described by Hofer and Hase. In the course of very early development, the epidermal cells appear to be slightly more cylindrical in form. I have not noted a similar change in the course of formation of the scale. As for the enamel organ itself, it occurs in advanced stages, so that the very early assumption of cylindrical appearance seems to me to be against its morphological significance. If it does occur in the later stages, it may be a transient phase or perhaps indicate a phenomenon that occurs very rarely, and it would be best to regard as artefacts such changes in structure which occur so rarely.

In both *S. fario* and *S. irrideus* there is present below the basal epidermal layer the basement membrane, which in *S. irrideus* is strongly developed and well marked (Fig. 2). The basement membrane appears to be double in nature; this appearance is due to the existence of a definite membrane and the presence of fine ectoplasmic layers of the basal epidermal cells, which, when continuous, present the form of a second membrane.

(c) *Cell layers, their arrangement and behaviour.*

In thin sections of Trout embryos at this stage, the layer of cells on the dorsal surface is seen to be several cells deep; as growth proceeds, the depth of the cells is reduced and one always meets with two distinct layers on both the surfaces (Figs. 5, 7, 9): the scale makes its appearance in between these four layers. The cells in these layers in the act of secretion undergo certain definite changes: whether the secreting cells are from the dorsal or from the ventral surface, the behaviour and modifications undergone are essentially similar in both cases. My preparations indicate that the cells and their nuclei grow considerably and become transparent. The nuclei of the dorsally placed cells become very much flattened and change gradually from a circular to a broadly conical form; the karyosomes break up into irregular fragments giving a granular appearance to the nuclear contents very different from the first. During this activity the cells with their nuclei remain attached to the scales between the concentric striations. (Fig. 14.) The fusion is so intimate that in sections the presence of cell walls associated with the nuclei may be demonstrated with very great difficulty.

The nuclei in the dorsal scleroblasts when they are properly fixed with Fleming without acetic and stained with Iron haematoxylin show at certain stages whitish areas which are small in the beginning, but later become confluent to form one large area (Fig. 7). In the ventral scleroblasts similar very minute areas appear in the nuclei and seem to be of the nature of secretions which build up the substance of the scale.

Another interesting feature of the dorsal scleroblasts, which seems not to have been recognised, is that these cells are remarkable in being very passive. There are no signs at any stage of excessive cell multiplication taking place on the margins or on the surface of the scale. At the edge of the scale the upper and lower layers merge so intimately that no distinction can be drawn between them (Fig. 6). There is no sign of excessive cell multiplication on the dorsal surface; whereas on the ventral surface the same phenomenon is actively displayed; one meets with cells and their nuclei in various stages of development. It may be therefore that the cells are in process of migration

from the ventral surface, from which the dorsal scleroblasts receive fresh reinforcements; the new elements at the margin continue to become associated with the upper scleroblasts.

There is considerable divergence of opinion regarding the polygonal layer (of Klaatsch) of the scale.

Klaatsch records this layer as occurring on the dorsal surface: "The superficial scleroblastic layer offers a very characteristic picture. Its polygonal-shaped elements simulate a flat epithelium. Between the protoplasmic bodies, which stain intensely in carmine stains (also in haematoxylin), there exists a network of a substance which does not tinge. This latter calls to mind a system of intercellular spaces." The histology of this cell layer was first studied by Klaatsch and the results of his investigations are contained in the following statements: "It attains a longish form and the nucleus reaches a more peripheral situation in the cell. By this means the nuclei of adjacent cells frequently approach one another, a nucleus-containing part from a nucleus-free section. In the latter, the following occurs with great regularity: at one spot the protoplasm loses its staining capacity, while this part retreats further and further towards the circumference, there arises a bright, almost circular spot (of about 6″ in diameter) which in form and size simulates a nucleus. Its interior shows no structure. While it stretches further and further towards the pole of the cell directed towards the nucleus, it eventually unites with the bright parts between the cells. The bright streaks between the cells owe their origin, just like the bright spots which I have described above, to a substance which has become differentiated from the remaining protoplasm." (Fig. 4.)

My interpretation regarding the nature and origin of the 'white spots' differs from that of Klaatsch; the origin of the white spots and his explanation of the elongation of the cells are not clear to me. It is evident in my preparations that the spot arises from within the nucleus (Fig. 4). The material from which it is derived is densely massed to one side of the nucleus; this loses its connection with the nuclear membrane, and moves away from it towards the centre of the cell. In its early stages the colourless mass simulates a nucleus, but later becomes diffuse and some of it no doubt unites with the intercellular substance; gradations between the early stages and the last stages are met with. It seems to me that the white spots certainly stand in genetic relation to the nucleus. In early, as well as late development, the nucleus is very closely surrounded by a whitish ring; this ring I think is a substance which is differentiated in the nucleus; it penetrates osmotically the nuclear membrane and becomes deposited round it in the form of a ring, giving to the nucleus the appearance of lying

in a large vacuole. This substance I consider as a secretion which accumulates round the nucleus and is finally eliminated in bulk.

If this derivation of the spots from the nucleus itself is not correct then it becomes extremely difficult to account for their origin, because in the ground substance, other than the nucleus and its karyosome, there appears to be no other structure and besides this fact there is no evidence for the belief that it arises as a differentiation process of the ground substance of the cell.

According to Klaatsch, the spots ultimately amalgamate with the intercellular meshwork ; this coalescence Hase, Ussow and Paget did not observe. If Klaatsch's view be correct the white spots in the cells and the intercellular substance should take up the same stain with the silver impregnation. The intercellular network is stained brown, that is, like the product of secretion (Fig. 10). My preparations also show the same product stained brown round the nuclear membranes Fig. 11.

The polygonal layer of cells described above is (contrary to the view of Klaatsch) really the more distal layer on the ventral surface ; reference, however, will be made to it again. In addition to this polygonal layer there is another more proximal layer to which no reference has been made before. This proximal layer is very closely adjacent to the scale (Fig. 9). As for the arrangement of the cells themselves, in these two layers throughout the series there is a great deal of variation in the appearance of the network of cells.

The distal cells-layer (polygonal layer of cells) on the ventral surface presents a very characteristic appearance. Figure 6 is a representation of the peculiar arrangement, which can be more clearly depicted than described. The entire scale layer is mapped out into several zones, which, as far as I have been able to make out, have no relation to the striation or to the growth of the scale itself. The most prominent region is the centre occupied by cells which are reticulate in nature ; this region has more or less the appearance of a sponge, or of a honey-comb, with large cells each having a nucleus ; this is surrounded by a zone of cells, which are slightly elongated and arranged in a concentric manner, followed by small rounded cells. This is next succeeded by a zone of prominent cells, constituting the largest portion of the scale. The cells are numerous and elongated radially ; as these proceed outwards they become small and circular and are followed by a zone of cells near the periphery, which are elongated in a direction tangential to the scale and shorter in a direction radial to it ; the last layer becomes gradually less distinct and is uninterruptedly continuous with the outer border of the upper margin. In some scales the early regions do not exist, and from the centre radiate the radial cells ; these are followed by the usual cells. Besides these types

there are scales in which other arrangements prevail. The precise conditions under which these various arrangements come to exist I cannot state. It seems likely that they represent different stages in the activity of the cells. The proximal layer of cells on the ventral surface, which lies between the polygonal layer and the scale, has the appearance of an irregular network of large polygonal cells (Fig. 9): The meshes vary in size, as does also the intercellular probably substance which becomes dilated and more prominent according to the quantity of the secretion accumulated in them. The nuclei in both the ventral layers are smaller and rounded, while those in the two dorsal layers are larger and greatly flattened. Besides these cells and their nuclei on the ventral surface, there are other nuclei which seem to be enclosed in several circular and irregular alveoli, giving the appearance of islets (Fig. 4). These nuclei are of varying size. They appear singly or in groups (fragmentation), showing no regular distribution, and appear to be in a special stage of activity. These nucleoli increase gradually in size and attain their maximum staining capacity. This is well seen on an application of Delafield haematoxylin, by which they acquire a beautiful blue tint.

Corresponding to the two layers of cells already described as lying on the ventral surface, there are two layers of polygonal cells at all stages of development of the scale on the dorsal surface (Figures 5 and 7). The difference between the layers of the two surfaces is that the intercellular material in the case of the dorsal cell layers is very poorly developed and the nuclei in these layers are much larger than entire cells in the previous stages.

(c) *Connective tissue.*

The great bulk of connective tissue constituted by the fibrous layer of the dermis is composed of bundles of connective tissue fibres, there being three sets of the latter, two sets running parallel to the surface diagonal to the long axis of the body, and the third set perpendicular to the other two sets. According to Hase the last set is really the diagonal fibres which have changed their direction. Paget believes them to be distinct, starting straight from the base of the fibrous layer without any previous horizontal course. I have followed the formation of fibres both in tiny embryos and in adult fish : in preparations fixed with Fleming without acetic and stained with Orcein and Weigert's Resorcin Fuchsin stain, the fibres appear very distinctly, and I am able to corroborate both Hase's and Paget's descriptions. Sections stained by the above method show very distinctly that the fibres belong respectively to the collagen and the elastic type. The first two sets, running parallel and diagonal to the surface of the body, consist of wavy bundles, which very often change their direction and run perpendicular to the surface of the body. When these happen to

be cut at different levels, they appear to arise straight from the base; the cut ends of these fibres are met with at different levels. These fibres belong to the first type and I have no doubt that it is to them that both Hase and Paget refer. The elastic tissue fibres, which are characteristic in running in a straight course occur singly. They arise distinctly from the base and run quite perpendicular to the surface (Fig. 3).

In the scale pocket the connective tissue cells take the form of small rounded or stellate cells with processes which seem to anastomose among themselves; these cells form a firm support for the scale. During development, as the posterior end of the scale is being inclined outwards, the cells of the cutis between the epidermis and the scale enter on a stage of active cell proliferation. They make their entrance between the basal membrane and the scale, and become associated with the scleroblasts at the ends of the scale. These cells, from their appearance and mode of staining, closely resemble connective tissue cells which have detached themselves and taken up this position; the cells from the two sources in the region of the peripheral sections of the scale become so much intermingled that they are distinguished with difficulty. Klaatsch and Ussow, however, have seen cell clusters in the same position, and attribute to them the relief on the upper surface of the scale. Klaatsch says: " At the same time there takes place an increase of dermis cells between the epidermis and the scales, and new elements thus become added to the scleroblasts on the upper surface of the scale, etc., etc. The scales thus become enveloped on all sides by loose connective tissue from which the scleroblasts receive new auxiliaries."

According to Hase, in the further course of the process of scale formation the transformation of cutis-cells into scleroblast takes place.

According to Paget, the papilla from its early origin acquires the form of a two-layered circular plate, between the upper and lower layers of which the scale makes its appearance. My observations support Paget's conclusions, but the scale papilla from its early origin is not two layered, but four-layered.

With regard to the connective tissue cells, it may be mentioned that they never take any part in the formation of the scale. The scale throughout its existence is so completely and symmetrically enveloped by the scleroblasts (Fig. 6) that it would be wrong to imagine a break occurring in these layers.

(d) *The development of the sclerites.* *

The sclerites make their appearance for the first time at the extreme out ends of the scale in both longitudinal and transverse

* On the dorsal surface of the scale are developed concentric inequalities which have been variously described as "lines," "ridges," "annli," "sclerites," etc., etc.

sections and present slight elevations of a substance which to all appearance is very similar to that of the upper layer of the scale. The explanation of Klaatsch, Ussow and Paget with regard to their formation is essentially similar: "The cells concerned arrange themselves so that they correspond exactly with the concentric ridges." In my preparations I find, firstly, that they occur at the extreme periphery (Figs. 7, 12); and appear to be laid down simultaneously with the other scale layers, and furthermore they arise within a cluster of cells. Just as the scale appears between scale papillae, so do also these appear between yet smaller cell aggregations, the sclerite papillae. In this smaller papillae the substance of the sclerite inclined towards the focus makes its appearance (Fig. 7). The cells on the outer side of the ridge, situated as they are on the circumference of a widening circle, are scattered as growth proceeds and lie between the adjoining sclerites; the cells on the inner side are usually kept well in position.

It is well-known that the sclerites in some fish formed during the summer are wide apart, while those formed in winter are nearer together. The surface of the scale is thus mapped out into well-marked regions: the summer and the winter bands. In other words, the scale denotes a well-marked rhythm. These facts of development have been utilised for determining the age of the fish. It seems just possible that the width between adjacent sclerites is determined by mechanical causes. The sclerites are formed in response to the phasic activities of the scale-pocket cells and the interval between each of the phases is represented on the scale in the form of sclerites.

Each scale develops in a pocket of the skin the scale-pocket ("*Schuppen-Tasche*," Klaatsch). In the Trout, the limits of the scale-pocket are well defined and the scale with its close investment of four cell layers lies free of the scale-pocket.

During summer, owing to more active growth, the scale-pocket increases in size and makes a larger space available for the scale, so that the activity of the scleroblasts lead to an extension of the peripheral portions of the scale. The formation of the sclerites is capable of explanation on the hypothesis that the growth of the scale-pocket takes place at regular intervals; like the sclerites of the scale, they exhibit rhythm. After the growth of the scale-pocket, there is a period of rest. At the next stage, the border of the scale abuts against the sides of the scale-pocket; as a result of extensive multiplication of cells on the ventral surface and enlargement of cells on the dorsal surface, there is an accumulation of cells at the borders of the scales on the dorsal surface. As no peripheral an extension is possible under these circumstances, the substance which builds up the sclerites accumulates between the cells, and takes the line of least resistance; in other words it takes a path of its own, subject to the restraints which are

imposed on it and the secretion accumulates in the interstices of the cells, which increase considerably in area by their own activity. At the completion of sclerite formation, the scale-pocket grows again; the strain upon the path of the scale being thus removed, growth takes the path of least resistance and the intermediate portions of the scale in between the sclerites come to be formed.

From this it follows that during summer, on account of environmental factors, the intervals of growth of the scale-pocket are long, leading to the formation of widely separated sclerites. In winter, for contrary reasons, the intervals of growth are greatly diminished, so that the sclerites, which come into existence, have not had enough time to be separated and are therefore crowded together. The sclerites denote the resting period, or they represent the arrested growth of the scale-pocket.

Previous records and points of interest.

An important record in connection with scale development—and also one of the earliest—is that of Klaatsch (1890). He was the first to work out the details of the development, and the figures representing his various sections are very instructive. He based his opinion of scale formation and growth upon the presence of minute osseous bodies in the first layer of the scale and he regarded this part of the scale as built up of the ordinary bone tissue. He believed that the second layer of the scale is formed from the connective tissue which is developed from the scale-pocket. Paget (1920) contradicts the above conclusion: he believes that the upper layer of scleroblasts gives rise to the upper layer of the scale, and the lower scleroblasts to the lower layer. These facts are in agreement with my observations.

It now remains to review briefly some expressions of opinion on the following questions:

(a) Which of the two scale layers is laid down first?
(b) Whether the covering epithelium is one cell thick or more?
(c) The changes undergone by the dorsal scleroblasts.

(a) With regard to the first, Klaatsch and Ussow are of opinion that it is the upper layer of the scale which is laid down first. Klaatsch states, (regarding the relation of the lower to the upper layers), " it is of significance that the upper layer of the scale exists for a long time alone, and that it is not till later, when the covering of the scale has completed itself, that the outer part of the scale first appears. There exists indeed a genetic relationship between both layers, and the external body layer has actually occasioned the formation of the second.

An examination of entire scales from the very earliest stages shows that the lower scleroblastic cells are active at all stages of their existence. They very early assume the characteristic polygonal

form, and the white spots are also present (Fig. 4). If Paget's view, (with which I agree) that the upper scleroblasts give rise to the upper layer of the scale, and the lower scleroblasts to the lower layer, be correct, then undoubtedly the lower scale layer exists at all stages. The polygonal layer of cells, which Klaatsch and Ussow take such pains to describe as lying over the scale, lies really below it. Attention was drawn to this fact by Paget and I can fully confirm his observations. To the activity of this layer they attribute the formation of the upper scale layer. In the light of these observations, it would seem that both Klaatsch and Ussow make contradictory statements, viz., the formation of the upper scale layer first and associated with it the lower active epithelium, in their view, the upper. The study of preparations stained with Delafield's haematoxylin corroborates this statement.

I know of no method of determining which of the layers is deposited first. The microscopic indications support Paget's statement that the two are laid down simultaneously. In the Cod, Tims (1902) showed that the inner layer which forms the fibrous plate develops first and on this the sclerites subsequently differentiate themselves.

(b) The question here to be decided is whether the covering epithelium is one cell thick or more.

In connection with the cell layers different accounts exist ; this is due to the fact that the Delafield's method of preparation obliterated the cytoplasmic outlines and made the limiting membranes invisible, (compare Fig. 14 with Figs. 5 and 9) and therefore both on the dorsal and on the ventral surfaces the double nature of the cell-layers was not clear. These layers in fact are capable of being lifted up and separated. Klaatsch, however, described several layers. He says that the cell structure on the external surface of the scale show differentiation into several layers of cells, and that these cells build up the substance of the first layer of the scale. In the opinion of Hase and Paget, the covering epithelium is only one cell thick.

If a reference is made to my figures the question is very convincingly answered. In preparations of scales mounted entire and stained by the special method, the four cell layers lying in different focal planes can easily be demonstrated, and the scale throughout life remains enclosed by these.

(c) The changes undergone by the dorsal scleroblasts described by Klaatsch, Ussow, and Paget are not clear to me.

According to Ussow, the cells which lie over the already secreted substance of the first layer of the scale use themselves up in the formation of the scale material (its first layer) much more rapidly than those of the under layer ; in later stages consequently one finds only nuclei without any trace of plasma.

Paget, in describing the striations, makes the following statements. "When the striae are once formed, practically no further growth takes place and the nuclei of the cells appear not to attach themselves so closely to it as at first; nevertheless, the whole of the plasma is used up in the process of stria formation." (Fig. 14.)

A study of preparations impregnated with silver makes it clear that the dorsally placed cells, which appeared to possess no cell-walls, have perfectly distinct cell limits like those on the ventral surface (Fig. 5). It is also apparent that the protoplasm is not used up in the building up of the scale, but on the contrary some product is separated from the cells and contributes to the formation of the scale. An interesting question arises with regard to the behaviour of the dorsal scleroblasts. Why do the cell limits on the dorsal surface of the scale not take up the same Delafield's stain which the ventral cells do readily? One explanation is that the fixing reagents, which were employed in the histological technique, destroyed these cell outlines.

Another explanation would be to regard the ventrally placed cells as young (meristem in plants), with plenty of protoplasm which readily takes up the stain, the ventral marginal cells as they pass on to the dorsal layer at the margins are no doubt older in history. These latter become in a sense static. The protoplasm becomes miscible with the ground substance with the result that ordinary methods of staining will not bring up the cell walls. By silver impregnation the colouring matter is deposited in the intercellular regions in the form of a precipitate, making the cell limits more opaque. In plants a similar phenomenon exists. In the meristematic cells, the cytoplasm occupies the whole volume of the cell and stains with the usual reagents. When the cells become old, the nucleus lies in a space surrounded by a thin film of cytoplasm connected by a number of strands with the cell-wall. In these cases the cell-wall takes up the stain because of the presence of cellulose in the cell-wall, the absence of which would make it just as difficult as appears to be the case in animal cells.

The cell membrane is to be regarded as part of the protoplasm itself, and it varies in its composition according to the chemical processes going on in the cell.

SUMMARY.

(1) A satisfactory technique for the investigation of developing teleostean scales has been described.

(2) The process of separation of the hard structure of the scale (upper and lower layers) is the work of four layers of cells, to which the term scleroblasts may be applied; these envelop the scale symmetrically throughout life,

(3) The upper scleroblasts have, throughout life, definite cell limits and become just as clearly polygonal as the lower scleroblasts.

(4) The upper scleroblasts give rise to the upper scale layer, the lower scleroblasts to the lower scale layer as well as to the upper scleroblasts themselves.

(5) The protoplasm and cell limits persist throughout life, the substance which builds up the scale arising as an intercellular secretion.

(6). The scale is situated in a special scale-pocket formed of connective tissue.

(7) The sclerites arise at the extreme peripheral ends of the scale and are formed by groups of cells.

(8) It is suggested that the form assumed by the scale and the development of the sclerites is due to intermittent growth of the scale pocket and to the several tensions and pressures to which the scale is subjected during growth.

EXPLANATION OF PLATES

All the Photo-micrographs were taken under a Watson's microscope provided with Apochromatic objectives and Watson's Photo-micrographic apparatus.

FIGURE 1. Trans. section through the skin of young Trout, 1/6" objective x 4 ocular.

Showing (*a*) Formation of dermal scale papillae,
(*b*) Differentiation of the dermis into an inner fibrous and an outer spongy layer.
(*c*) Musculature.
Trout 3,5 cms. long.

FIGURE 2. Trans. section through the skin of young Trout, 1/6" objective x 4 ocular.
(*a*) Epidermis with mucous cells,
(*b*) Cuticularised lower borders of the basal epidermal cells,
(*c*) A definite basement membrane,
Trout 2.5 cms. long.

FIGURE 3. Longitudinal vertical section of skin of Trout to show relation of fibres. Weigart's Resorcin. Fuchsin stain.
1/12" objective x 4 ocular.
(*a*) Collagen fibres running in bundles and showing a change in their direction,
(*b*) Elastic fibres arising straight from the base and running singly.

FIGURE 4. A part of scale of Trout. Surface view of the ventral surface. Stained Delafield's Haematoxylin. 1/6″ objective x 4 ocular.

(*a*) Large polygonal cells which exhibit every variety of shape.
(*b*) White intercellular spaces between the cells.
(*c*) Whitish rings surrounding the nucleus. The white spots are massed to one side of the nucleus and in some cells separated from it.
(*d*) Excessive nuclear fragmentation.

FIGURE 5. Part of scale from the dorsal surface. (Nitrate of Silver preparation). 1/6″ objective x 4 ocular. 2 layers of scleroblastic cells.
Impossible to demonstrate without the silver method of staining.

FIGURE 6. Part of scale, stained with Delafield's and Eosin. 2/3″ objective x 4 ocular.
Showing general relation of distal ventral layer of cells.

FIGURE 7. One end of the scale in section.
1/12″ objective x 4 ocular. Relation of scleroblasts to the scale.

(*a*) Cluster of cells at the cut ends where a ridge is in process of formation.
(*b*) Also characteristic arrangement of cells which form the ridge.
(*c*) Note whitish spots in nuclei.

FIGURE 8. Transverse section of scale with several layers of scleroblasts on the outer surface.
1/6″ objective x 4 ocular.

(*a*) The more proximal cells attached intimately to the scale.
(*b*) The lower cells have separated away from the scale and appear more markedly flattened than those of the upper layer.

Trout 3·5. cms. long.

FIGURE 9. Part of scale. Surface view of ventral cells from the anterior region. (Nitrate of Silver preparation). 1/6″ objective x 4 ocular.

(*a*) Two layers of scleroblastic cells.
(*b*) The layer of cells (proximal) attached to the scale has very large spaces.

FIGURE 10. Part of scale. Surface view of the ventral surface; only one layer in focus. (Nitrate of Silver preparation).
1/6″ objective x 4 ocular.
(*a*) Intercellular substance as well as the diffused secretion stained brown.

FIGURE 11. Part of scale. Surface view of the ventral surface. (Nitrate of Silver preparation).
1/12″ objective x 4 ocular.
(*a*) The substance massed to the nucleus stained brown.

FIGURE 12. End of scale in long. vert. section.
1/12″ objective x 4 ocular.
(*a*) The formation of the ridge at the extreme end.
(*b*) The upper homogeneous layer of the scale raised into ridges.
(*c*) The stratification in the lower lamellar layer just visible.

FIGURE 13. Transverse section of scale.
1/6″ objective x 4 ocular.
(*a*) Position and relation of scleroblasts of the two surfaces at the end.
(*b*) Cuticle bordering the cells.

FIGURE 14. Part of scale from the dorsal surface (Delafield's Haematoxylin preparation) Compare with Figure 5.

FIGURE 15. Transverse section of scale.
(*a*) Cluster of connective tissue cells at the end.

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Fig 1

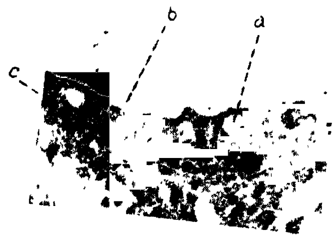

Fig 2

Fig 3

Fig 4

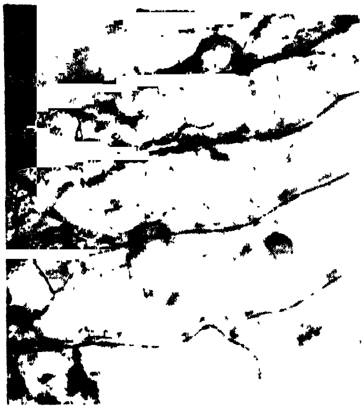

Fig 5

Fig 6

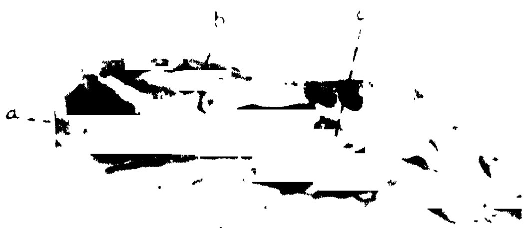

Fig 7

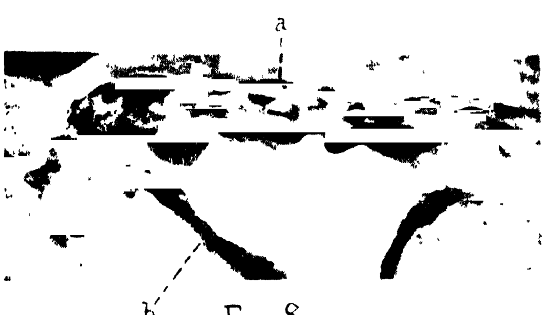

Fig 8

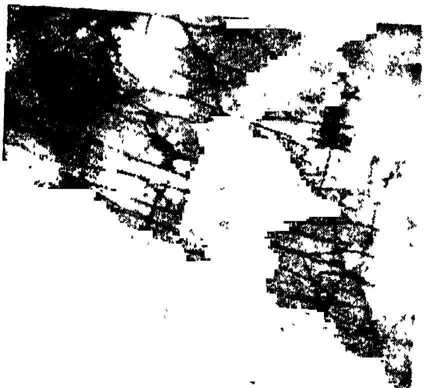

Fig 9

Fig 10

Fig 11

Fig 12

Fig. 13.

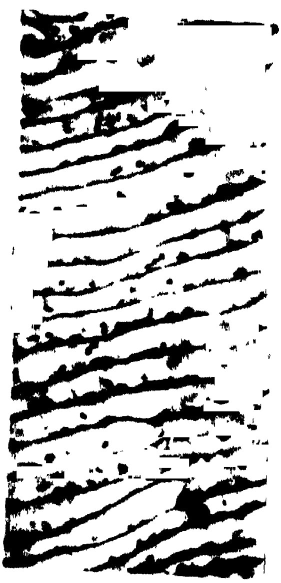

Fig 14.

Fig 15

ON THE PHASICAL MORPHOLOGY OF THE THYMUS GLAND IN SOME COMMON EUROPEAN FISHES AND IN TWO CYCLOSTOMES.

By

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(with 6 text-figures and 1 plate.)

CONTENTS : Introduction—Material—The Thymus in the Teleosts—The Thymus in the Elasmobranchs—The Thymus in two Cyclostomes—Conclusions—References.

INTRODUCTION.

The present paper on the Phasical Morphology of the Thymus Gland in some Common European Fishes and in two Cyclostomes is based on the work done by me in the Oceanography Department of the University of Liverpool at Liverpool, while working on the Phasical History of the Thymus Gland in Plaice of Various Ages, etc., already published in the fifth part of the first volume of this Journal. As indicated in the title of this paper, this survey is not complete and requires to be supplemented by an examination of the thymus gland in some more fishes, particularly specialized ones. The work is being continued by me in the Zoology Department of the Royal Institute of Science, Bombay, and its results will be published in due course.

MATERIAL.

This investigation was carried on mostly with material fixed in formalin. The specimens were well preserved and in sections produced satisfactory results when stained with Mayer's Glychaemalum.

THE THYMUS IN THE TELEOSTS.

Pleuronectes limanda.

(Specimen : 24 cms. long.)

The thymus in this specimen was in position and shape similar to that of the plaice which has been described in detail in my paper thereon already published in this Journal. It was 5 mm. long, 2 mm. broad and 1 mm. thick. It consisted of a few rounded and rod-shaped lobules loosely packed together. On its upper surface it consisted of two rows of lobules.

In another specimen 29 cms. long it was 6·5 mm. long and 2 mm. broad. Thus in both of these it was evidently smaller than the thymus in the plaice of the same length.

Rhombus laevis.

(Specimen : 12·5 cm. long.)

The thymus of this specimen was in its normal position. It was 3 mm. long, 1·5 mm. broad, and ·5 mm. thick at its posterior end. Anteriorly it tapered as in others.

Solea lascaris.

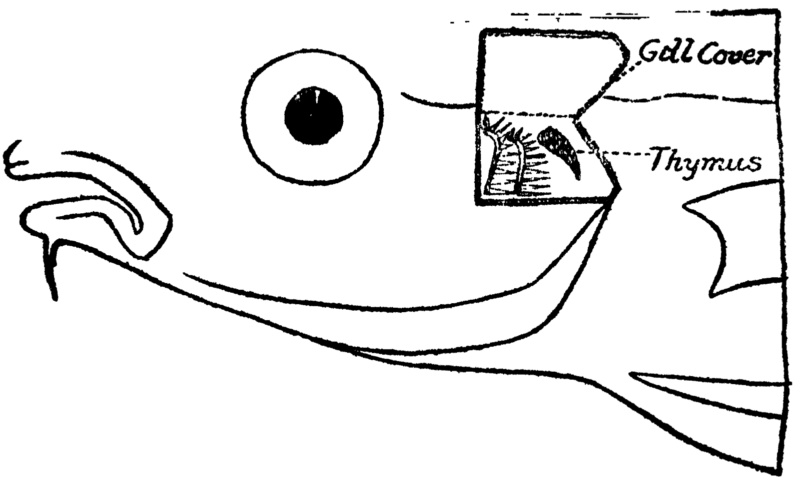
(Specimen: 14 cm. long.)

In this fish the thymus on the ocular side was in its normal position. It was 4 mm. long, and 1·5 mm. thick in the middle. It tapered both anteriorly and posteriorly. The sex of the fish was indeterminate.

Gadus morrhua.

(Specimen: 22·5 cm. long.)

In order to expose the thymus of this fish (Text-Fig. 1), the gill-cover was cut in the middle from below and the posterior half was turned over. Then as in the plaice the thymus was seen through



TEXT FIG. 1

Dissection of a 22·5 cms. Cod to expose the thymus on the left side.

the thin skin at the posterio-dorsal corner of the branchial chamber behind the gills. After removing the skin the thymus was seen filling up the corner between the post-temporal and the supra-clavicle. In this lateral view it measured 5 mm. long and 2·5 mm. broad in the middle. It was more compact than that of the plaice and appeared to be not divided into lobules. When dissected out, it was found to be narrowing inwards and downwards so that it resembled a wedge inserted from the side.

In a cod 65 cm. long it was 23 mm. long and 9 mm. broad in the middle. It looked more like a mass of thick fibrous connective tissue than a glandular one. In section it was found that the proper thymus

tissue was covered with a coat of connective tissue varying in thickness from one to one-half millimeter.

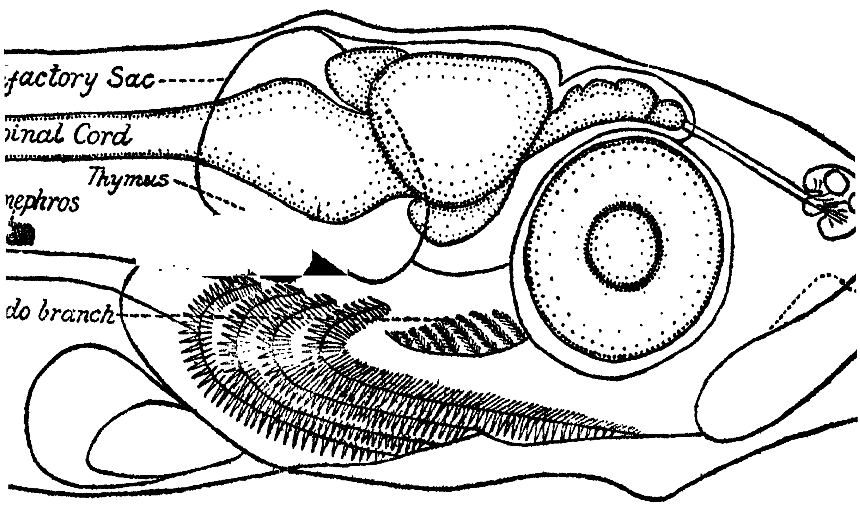
Gadus aeglefinus.

(Specimen : 21·5 cm. long.)

The position of the thymus in this specimen was the same as in the cod. It was covered with a thin layer of argented and was evidently larger than the thymus in the cod of the same length. It was as compact as in the former. It was 7·5 mm. long and 5 mm. broad. It bulged out into a lobe in the middle of its external surface and was 4 mm. thick. In both the Cod and Haddock it was broad anteriorly and tapered obliquely backwards and downwards.

Clupea harengus.

From a sample of white-bait from Morecambe Bay a specimen 34 mm. long was sectioned and the reconstructed outline of its thymus was introduced into the lateral view of another specimen of the same length (Text-Fig 2). At this stage a young herring is not easily



TEXT FIG. 2

Lateral view of a 34 mm. Clupeid with the thymus and pronephros shown in their places.

distinguished from its congeners pilchard and spratt. Moreover all these are found together in one and the same catch. But as all are practically of the same age, so far as the survey of the thymus is concerned, it should not make much difference whether it was a young Herring, or Spratt, or Pilchard.

The thymus was in the form of a thin oval pad applied to the external surface of the auditory capsule. It was covered over by the mucous membrane of the branchial chamber. It measured ·75 mm.

in length, ·7 mm. in breadth and ·15 mm. thick in the middle. As it was applied to the curved external surface of the auditory capsule, it appeared less broad than it really was, when its outline was projected to a single vertical plane.

In connection with its histology much could not be observed in a series of 20μ sections of a specimen preserved in 3% Formalin. Still it was noticed that there were no coagulum balls. Its external margin was in contact with a thin layer of branchial epidermis and its internal margin was not definite. Moreover numerous thymus cells were seen in the adjoining connective tissue all along its internal margin.

The pronephros was behind the thymus by as much as the thymus was behind the eye. Lymphocytes were accumulating in it.

In a young herring 4·5 cm. long from the same locality, the thymus measured 2·2 mm. long, 1·9 mm. broad and ·6 mm. thick in the middle. Thus during this time it had trebled its former length and thickness while its increase in breadth was relatively less. Now it nearly reached the head kidney. Its internal margin was quite definite except in the middle. In the connective tissue adjoining this central part a large number of thymus cells were seen. Along its external surface underlying the epidermis a clearer area could be distinguished. It was ·06 mm. thick or in other words one-tenth of its whole thickness. It contained relatively a less number of thymus cells and the interspaces were larger. Irregular clearer spaces and pycnotic thymus cells were seen scattered throughout the thymus.

In a young herring 12 cm. long and less than two winters old the thymus measured 5 mm. long and 2 mm. broad. It appeared to be pushed out towards the epidermis by the underlying muscle and it appeared as a small ingrowth of the epidermis in that region. It clearly showed that its growth was not keeping pace with the growth of the body even before the fish became mature.

Clupea sprattus.

In a specimen 7·5 cm. long and three years old the thymus had completely disappeared. Its place was occupied by fibrous connective tissue.

Salmo fario.

Deanesly has recently studied the life history of the thymus in this fish. It resembles the life history of the thymus in Herring. Sections were cut of a newly hatched larva of this fish and it was observed that the thyroid was also rudimentary as the thymus.

Centrolophus niger.

(Specimen: 52 cm. long.)

In this deep sea form the thymus was altogether absent. While searching for the thymus the lymphoid tissue of the head kidney was

easily reached as the intervening connective tissue was very loose. The head kidney looked like the thymus but in sections its true nature was revealed. Hammar has recorded the thymus in a specimen of *Centronotus gunnellus* 12·5 cm. long.

THE THYMUS IN ELASMOBRANCHS.

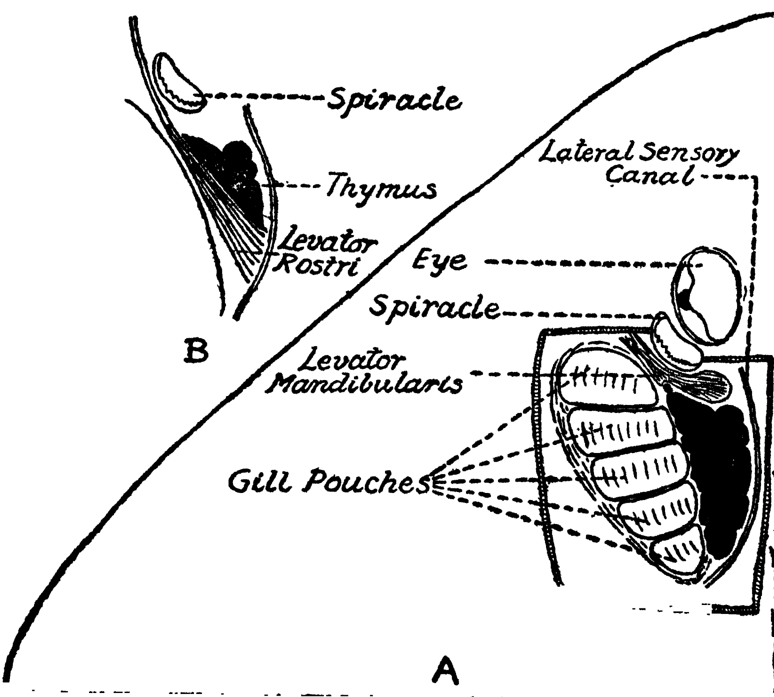
Chimaera monstrosa.

In a specimen 70 cm. long it was found to be absent. But Hammar has recorded it in this species and he has stated that the process of involution begins in specimens of about 75 cm. length.

Raia maculata.

(Specimen: 18 cm. across the body.) Text-Fig. 3.

The thymus of each side was situated in this specimen on its dorsal side behind the spiracle and on the mesial side of the gill pouches. When the integument in this region was removed a layer



TEXT FIG. 3

Thymus of Raia maculta. A, Dissection of 18 cm. wide specimen exposing the thymus on the left side. B, Part of the thymus exposed on removing the skin and connective tissue.

of about 15 ampullary tubules was seen lying in the underlying loose connective tissue. When the tubules were removed a part of the thymus

was exposed between the lateral sensory canal and the gill pouches. The remaining part along the gill-pouches was covered by a paddle-shaped muscle whose tendon passed straight to the anterior margin of the snout by the outer side of the spiracle. When this muscle was removed the roughly triangular dorsal surface of the thymus was fully seen. Its outline was modified so as to fill in the space among the surrounding organs. On its mesial side it closely followed the sigmoid curve of the lateral sensory canal and on its external side it pushed its way between the gill-pouches. Between its anterior side and the spiracle was seen the stout levator mandibularis muscle. When it was separated from the surrounding parts it was seen tapering to an edge on the ventral side. It thus roughly resembles an elongated prism. All along its surface it consisted of rounded lobules closely packed together.

When the connective tissue enclosing it was removed it was seen to be made of five lobes. These lobes corresponded to the gill-pouches but their margins alternated with the margins of the pouches.

It was 19 mm. long and 7·5 mm. broad. In a specimen 26·5 cm. across the body the thymus was 16 mm. long and 7 mm. broad.

In a specimen 34 cm. across the body the thymus was so well developed that its dorsal surface, instead of being flat as before, now bulged out between the lateral sensory canal and the rostral levator muscle. The latter now occupied a trough between the thymus and the gill-pouches. The thymus was 22·5 mm. long and 10·5 mm. broad.

Raia clavata.

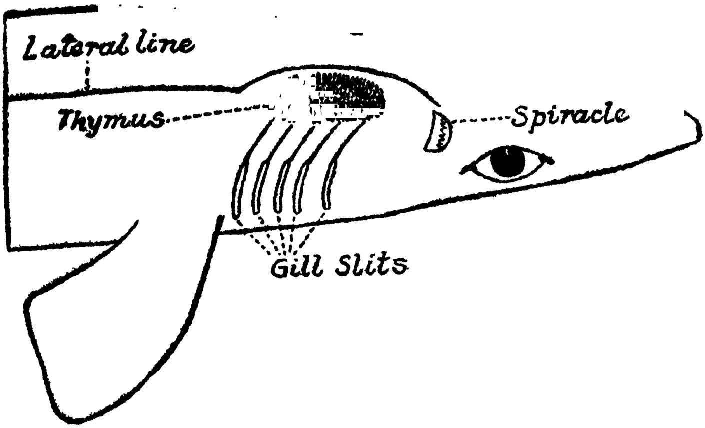
In this fish the thymus occupies the same position and has the same shape as that in the former ray. In a specimen 9 cm. across the disc it was 8 mm. long and 3·5 mm. broad. In a specimen 20 cm across the body it measured 11 mm. long and 5 mm. broad, and in a specimen 49 cm. across the body it was 28 mm. long and 18 mm. broad. The connective tissue covering it was fibrous and the levator rostri muscle was shifted towards the gill-pouches. It appeared to be proliferating at the edge but its microscopic study showed that it was really involuting.

Acanthias vulgaris.

(Specimen : a foetus 19 cm. long.)

The foetus had a yolk-sac, as large as itself, attached to it. Its thymus (Text-Fig. 4) was situated on each side immediately below the lateral line in the region of the gill-slits. When the skin was removed it presented an ellipsoid area made of numerous small lobules. Some of the lobules were elongated but most of them were rounded. They appeared to be arranged in parallel rows running between the lateral line and the gill-slits. It measured 11·5 mm. long and 4·5 mm,

broad. It was comparatively very thin as it consisted of a single layer of the lobules.



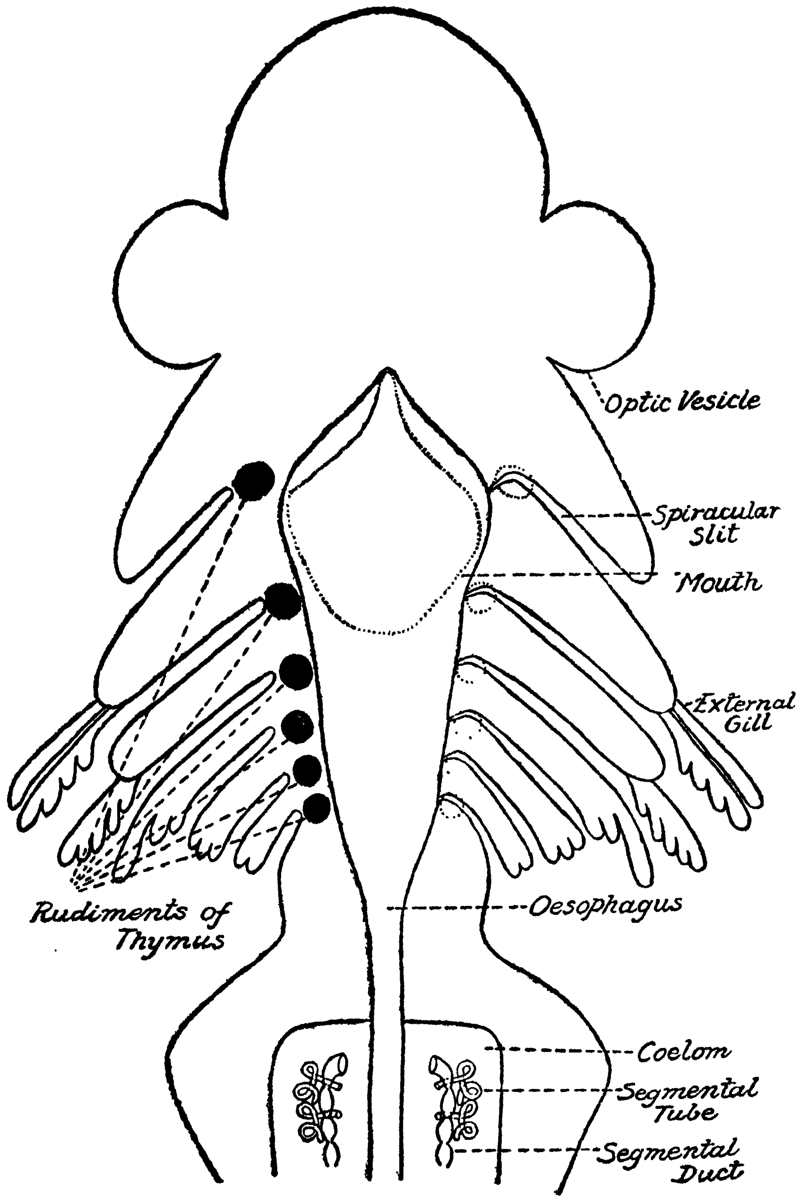
TEXT FIG. 4
Lateral view of a foetal Acanthias vulgaris 19 cms. long showing the thymus on the left side.

In a foetus 21 mm. long (Text-Fig. 5.) the thymus was represented by six rudiments on each side at the dorsal ends of the gill-slits. The foetus was very young as its eyes were represented by optic vesicles seen as lateral out-growths in front of the spiracle or the most anterior gill-slit. The fore-brain bulged out ventrally between the optic vesicles. On account of the cranial flexure the mid-brain formed the anterior end of the long axis of the foetus. The mouth was a deep diamond-shaped pit behind the fore-brain. Filaments of external gills were seen coming out of all the five gill-slits. The pectoral and pelvic fins were represented by tiny lateral flaps.

In Text-Fig. 5 the positions of the thymus rudiments are shown in the dorsal view of the foetus. Their outlines were reconstructed from a series of 20μ transverse sections. The first thymus rudiment on each side was in connection with the dorsal edge of the spiracle and was situated midway between its external and internal openings. It was like an elliptical plate thickened in the middle. It partly covered the dorsal edge of the spiracular slit and chiefly spread down its posterior wall. In a longitudinal section of a foetus passing through it, it was like the root-cap seen in a longitudinal section of a root-tip. In sections the area of the thymus rudiment was marked by the absence of the basal membrane between the hypoblastic epithelium and the surrounding connective tissue. Moreover the thymus rudiment (Plate I, Fig. 1) or the part of the epithelium was thickened and consisted of rounded, loosely packed cells unlike the columnar closely packed cells of the surrounding epithelium. In sections the surrounding epithelium was

seen to have thickened but it may have been due to the sections being not quite transverse to it.

In a specimen 70 cm. long the thymus was quite vestigial.

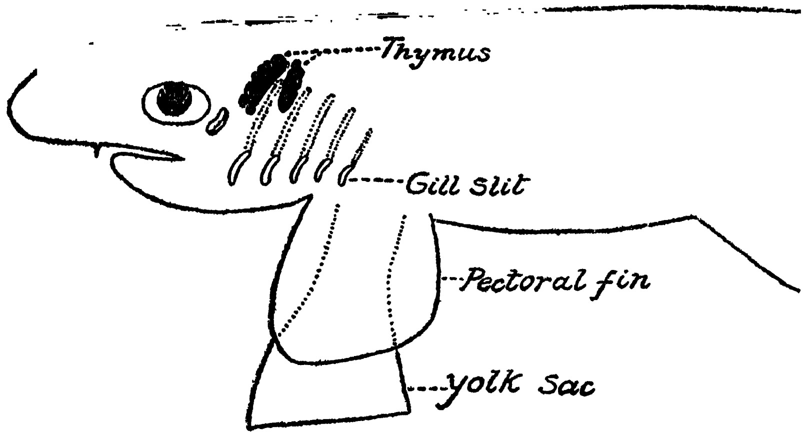


TEXT FIG. 5

Dorsal view of a foetal Acanthias vulgaris 22 mm. long with the thymus rudiments and the primitive kidney shown in their places.

Scyllium canicula.

In an embryo 8 cm. long (Text-Fig. 6) the thymus was well developed and consisted of two lobes lying dorsal and just anterior to the



TEXT FIG. 6

Lateral view of an embryonic Dogfish 8 cm. long showing the thymus.

first two branchial arches respectively. The first lobe was larger and longer than the second. Both of them were very close to each other at the dorsal end. Each of them consisted of a few lobules.

In a dogfish about 70 cm. long the thymus was quite inconspicuous. When it was sectioned with its surrounding connective tissue it was found to be reduced to a few minute lobules from which a large number of thymus cells had emigrated and left vacant spaces behind.

THE THYMUS IN TWO CYCLOSTOMES.

Lampetra fluviatilis

(Specimen : a larva 6·5 cm. long.)

This specimen preserved in methylated spirit was secured from the British Museum (Nat. Hist.) through the courtesy of Dr. J. R. Norman. In this specimen (Plate I, fig. 2) the thymus was represented by a pair of irregular nodules of the thymus cells situated in the neighbourhood of each of the external branchial pores. One of them was dorsal and the other was ventral to the latter. Immediately external to the nodule there is a large blood sinus and the thymus cells appear to form a part of the contents of the blood sinus. But a good differentiation was obtained by staining the sections with Glychaemalum, which proved their distinctiveness. As this series of sections was not complete the number of such nodules forming the thymus rudiments could not be determined. But Schaffer has stated that all branchial pores have similar pairs of nodules and therefore the thymus in the larva of this Lamprey consists of twenty-eight nodules.

In a Brook Lamprey (Lampetra planeri), 7·5 cm. long the thymus was absent.

CONCLUSIONS.

The present survey of the thymus gland of fishes deals with species representing the large morphological divisions of fishes. Thus it includes notes on the thymus of some of the round-bodied and flattened bony fishes, some Rays and Dogfishes, a Holocephalian and two Cyclostomes. It also includes a reference to a deep-sea form. From the condition of the thymus observed in various fishes at various stages of their life-histories it is evident that the organ is present in all fishes but that the organ has a variable origin and a variable duration in different kinds of fish. While in the Rays the thymus rudiments are seen in connection with all the five gill-pouches, in some Dogfishes it is confined to the first two gill-pouches only. Similarly while the thymus is completely reduced at or before the time of maturity in Herring and Trout, it continues to grow in Rays and Flat-fishes, and also in Cod. This suggests that no correlation could be established between the involution of the thymus and the maturity of the gonads in fish. It further suggests that in some fishes like Rays and Flat-fishes the thymus continues to be active and functional beyond the time of their maturity.

When the size of the thymus in various fishes is considered it strikes one that the organ in flattened and sluggish fishes like the rays and flat-fishes is more developed than in the round-bodied and active fishes.

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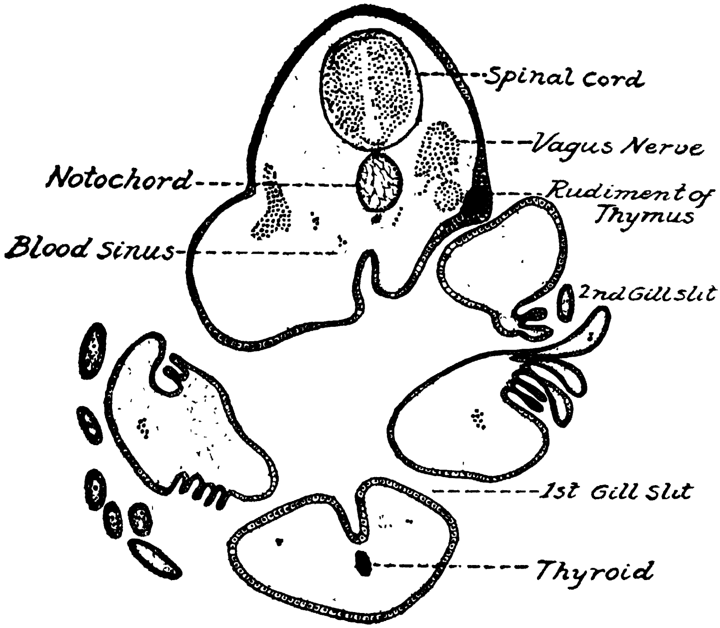

PLATE I, FIG. 1
Transverse section of a foetal Acanthias vulgaris 21 mm. long, passing through the thymus rudiment of the third gill-slit.

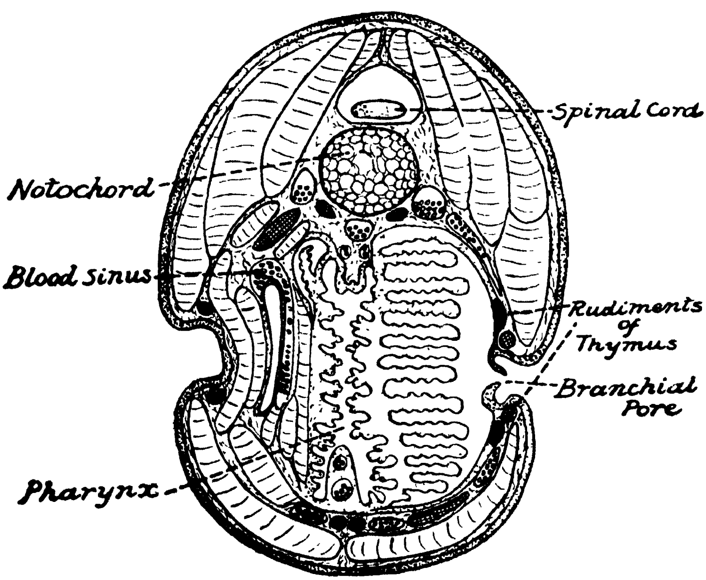

PLATE I, FIG. 2
Transverse section of a larval Lamperta fluviatilis 6·5 cms. long, passing through a branchial pore on one side.

STUDIES ON THE HONEY BEE, *APIS INDICA*—I

By

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(4 Text-figures and 4 Photographs)

Introduction and Historical Background.

A study of the indigenous honey bees has been undertaken at the suggestion of Professor C. J. George, and though the work will take many years for completion, I have no hesitation to publish the following few observations in view of the interest they will create in Apiculture in the Bombay Presidency. I take this opportunity to record my indebtedness to Dr. George for offering me his valuable guidance in pursuing this study.

Apiculture as a side line industry to Agriculture is practised in many countries. In some of these countries the industry is carried out on a large scale. Figures are not available on the output of honey for all these countries, but it is well-known that thousands of tons of honey are exported by Canada, Australia and the United States of America. Though the possibilities of apiculture in India have received the attention of Government as early as 1883 when, as a result of an enquiry, the Government of India published the replies from local Governments under the title " A Collection of Papers on Bee-keeping in India", the industry is still in an infant state in India. One of the early attempts at culturing bees on scientific lines was made by the Agricultural Research Institute, Pusa. In 1910 and 1911 the Institute imported some colonies of the European bee. Later Mr. T. Bainbrigge Fletcher, Imperial Entomologist, published two articles on bee-keeping in the Agricultural Journal of India, Vol. VI, Part IV. A further consolidated account came out in 1914 as Bulletin No. 46 of the Agricultural Research Institute.

During the years 1911–1916 Father Newton, S. J., conducted trials on the cultivation of the Indian bee *Apis indica.* His results were published in an article in the Agricultural Journal of India, 1917. The Department of Agriculture, Mysore, began the study of apiculture with the Indian bee about ten years ago and have made good progress. Mr. J. S. Baldry attempted culture of the Indian bee at Narsapur during 1926-1929. The account of his experience was published in the " Illustrated Weekly of India ", dated 7th December 1930, 28th December 1930, 15th February 1931, and 22nd November 1931.

Recently the Rural Reconstruction Branch of the South Indian Y. M. C. A. has taken up apiculture (culture of *Apis indica*) with a view to popularize it among the Indian farmers. They have their centres at Coimbatore, which is subsidized by the District Board, and at Marthandam (Travancore). The cultivation of the Indian bee has also been attempted at the Agricultural College and Research Institute, Coimbatore.

Outline of the Habits of the Indigenous Species of Apis.

There are three species of Apis in India,—*Apis dorsata*, *Apis indica* and *Apis florea*. In some of their habits the three species resemble a good deal, though the comb building and nesting habits are very different.

Apis dorsata (Fig. 1) is the biggest of the three and is primarily a dweller of the forest. The Western Ghats afford ample favourable

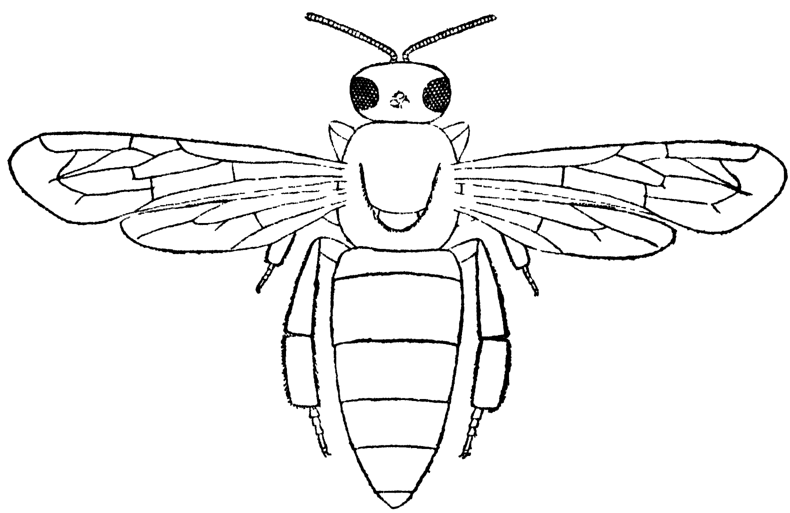
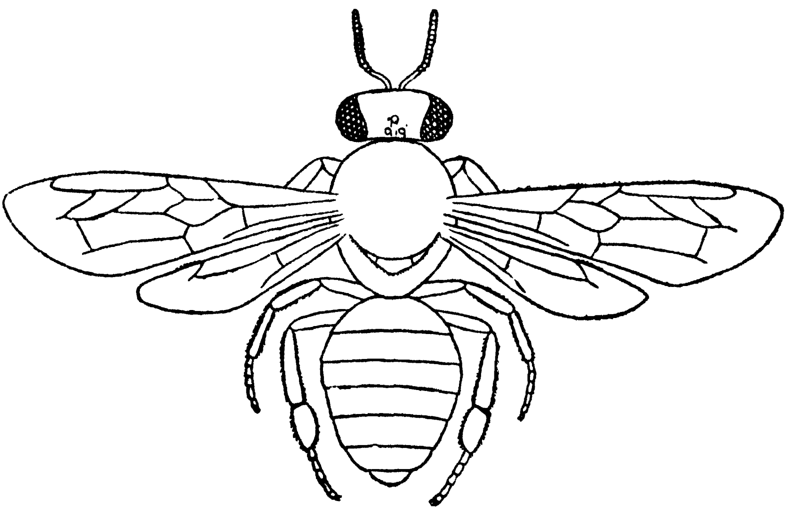


Fig. 1. *Apis dorsata* Fabr. (worker) x 3·3.

ground for it. It is usually known as the "rock bee", and builds its hive on high situations, and the shelter from an overhanging cliff is a very favourite haunt for it. It always keeps its nest a certain height or more from the ground, thirty feet being the lowest noted so far in this part of the country. Each colony has only a single enormous comb. The average size of a comb is about 18" × 18", though combs of 39" × 18" are on record (Gosh—Rept. Third Ent. Meet., Pusa, 1919). The cell measures roughly $\frac{1}{5}$ of an inch in diameter and is $\frac{7}{10}$ of an inch in depth. The bee is very efficient on the wings and can fly upto 300 yards at a stretch. Its long abdomen acting like a rudder adds to the efficiency of flight. When irritated it is ferocious and animals and human beings dread it,

It is believed that *Apis dorsata* has a migratory habit, living in the hills during the Summer and migrating to the plains in the rainy season. This record under careful scrutiny does not seem to be authenticated. A hive of this insect has been in existence under the eaves of the Wilson College continuously for the last two years. A second swarm which settled early in June last is still continuing in Bombay though the Summer has set in. The belief also proves unreliable when we analyse the conditions absolutely essential for such a migration. In the first place it must be credited with the power of anticipating the coming change of weather. There are no grounds to make such an assumption. Further the workers and the queen will have to fly a long distance in order to reach either destination, and even a six-months old queen will be unable with her heavy abdomen to accomplish that feat.

Apis florea (Fig. 2) the smallest of the three species, builds its nest at lower heights than does *Apis dorsata*, but like the latter it builds



Pig. 2. *Apis florea* Fabr. (worker) x 6·6.

single combs. Its comb does not measure more than 6″ × 6″. Each cell is only $\frac{1}{10}$ of an inch in diameter and $\frac{3}{10}$ of an inch in depth, or just half that of *Apis dorsata*. It is a poor honey gatherer but its honey has a fine taste. It is a poor flier, much less efficient than *Apis dorsata* and *Apis indica*. It has been found that it is subjected to attacks by a mite.

Apis indica (Fig. 3) is intermediate in size between *Apis dorsata* and *Apis florea*. It builds its hive at lower heights than *Apis dorsata*. It inhabits hollows or crevices on trees, walls or some masonary constructions. Like *Apis mellifica*, the European species, it builds parallel combs and is therefore thoroughly suited for domestication. It

is found both on the hills and in the plains. Its combs are roughly 8" × 6" and each cell is about $\frac{7}{40}$ of an inch in diameter or slightly

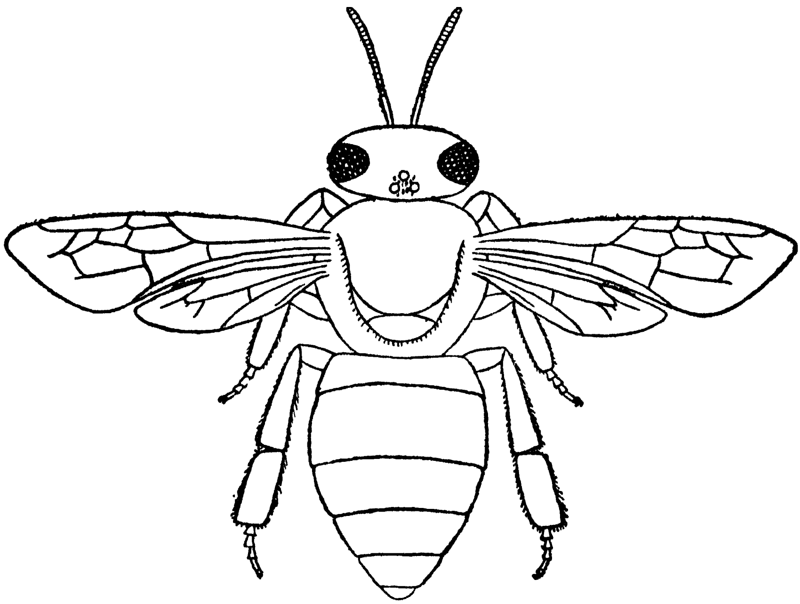


Fig. 3. *Apis indica* Fabr. (worker) x 6.

smaller than that of *Apis dorsata*, and about $\frac{7}{20}$ of an inch in depth. It is a poor flier when compared with *Apis dorsata*, though more efficient than *Apis florea*. It cannot withstand the vicissitudes of weather so well as *Apis dorsata*. It is as docile as *Apis mellifica* and as easily domesticated.

Though *Apis dorsata* is a more efficient honey gatherer and flier it is unsuitable for domestication on account of certain characteristics. It is ferocious and does not submit to enclosed hives. *Apis florea* is too inefficient. That leaves *Apis indica* as the only indigenous species suitable for apicultural purposes, and its behaviour will be evident from a perusal of the literature referred to. Moreover it is free from diseases and attacks by parasites.

In Bombay the hot months from March to June is the period of intense activity. The comb-building is entirely confined to this period. Surplus honey will be available only during this period. That leaves us with only one chance of gathering honey in the year. The breeding season follows immediately this season, and the new queens emerge with the advent of good weather, in September and October. Swarming, therefore, takes place from October to November.

During the monsoon and the cold weather their activity is seriously hampered, not only on account of the adverse weather but also for want of sufficient food. Their food requirements could be

easily analysed under two heads—the nitrogenous pollen and the carbohydrate honey. The former is required in enormous quantities for the upkeep of the hive and lack of pollen in the field compels them to invade its honey store. So, one necessary requirement in order to ensure honey collection is the ample supply of pollen. Graminaceous plants of different kinds yield the best pollen in large quantities. Sorghum and Maize are exceptionally good yielders of pollen. Fields of these two crops are absolutely essential during Summer in order to get some quantity of honey from the hive. Species of Malvaceous and Leguminous plants also supply tolerably good quantity of pollen. Plants of other orders are of little value as pollen yielders. The bees have a habit of storing pollen whenever it is available in quantities. So, in any hive after a good season one can find a good store of that stuff.

Honey is as essential for the bee as pollen. The common honey yielding plants are again large Leguminous trees like Tamarind and Malvaceous plants like Cotton. Garden plants of the order Compositae e. g. Zinnia yield both honey and pollen and are eagerly sought after by the bees. Another favourite plant is Antigonum and it is visited by all the three species both for honey.

Apis indica if all circumstances are favourable will yield about 10 to 15 pounds of honey per annum per hive. In any scheme of apiculture the yield could be expected only by a careful adjustment of several factors, the more important of which are—the location of the hive in a situation amidst vegetation yielding both pollen and honey; protection from sun and rain and wind should be naturally provided; artificial feeding during periods of scarcity should be resorted to. Some water should be provided if natural sources of water are not available. Bees excrete their fæcal matter in a squirt of liquid when on their wings and commensurate with the energy required for flight and a high temperature maintained in the hive a water supply is absolutely essential to keep the bee in good tone.

The Artificial Hive.

An artificial box hive made of teak wood is built in three pieces. The accompanying illustrations show a hive of the usual size used for *Apis indica.* The basal piece (Fig. 4 A.) measures $9'' \times 8'' \times 6\frac{1}{2}''$ on the inside and carries 7 moveable frames (*m. fr.*) $8'' \times 6''$ on which the wax combs are built. The frames remain $\frac{1}{2}$ inch above the bottom and also leave sufficient space from the walls of the box on which they rest. Between two adjacent frames also, a space of $\frac{1}{4}$ inch is left for the bees to pass through. The entrance to the hive (*ent.*) is situated at the base, and the projecting foot board (*f. b.*) acts as a platform for the bees' to alight before entering the hive. The middle piece (Fig. 4 B.) is 3 inches high and accommodates also 7 smaller frames (*m. fr.*) $8'' \times 2\frac{1}{2}''$. The topmost piece (Fig. 4 C.) forms the roof of

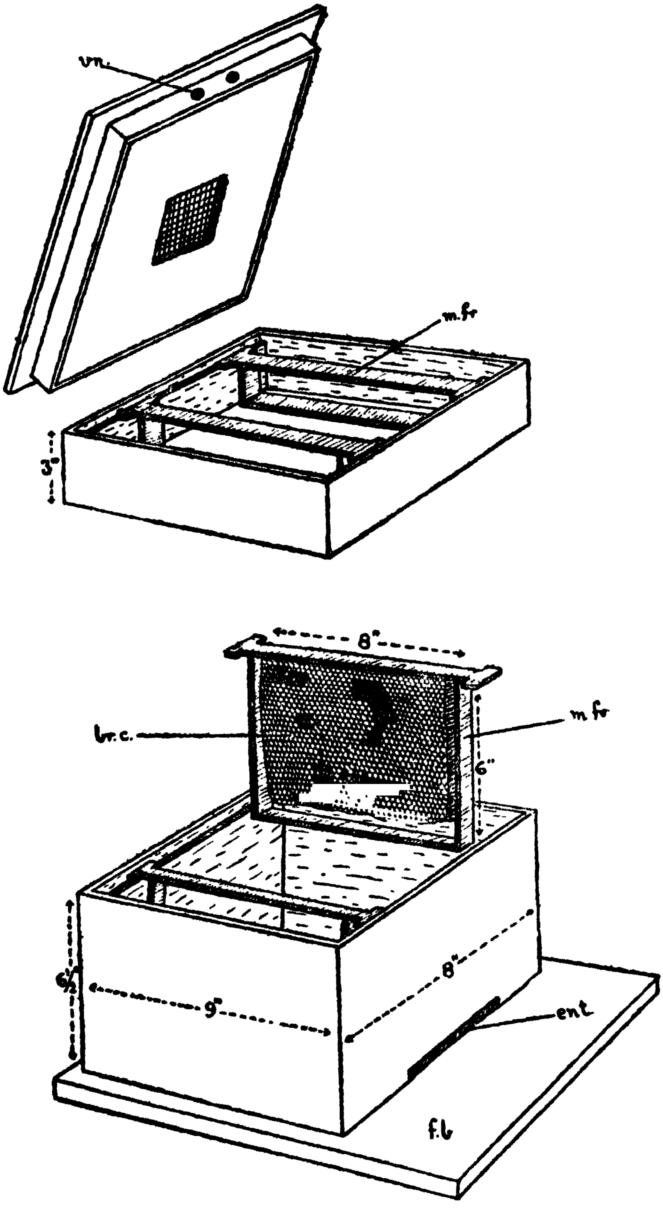
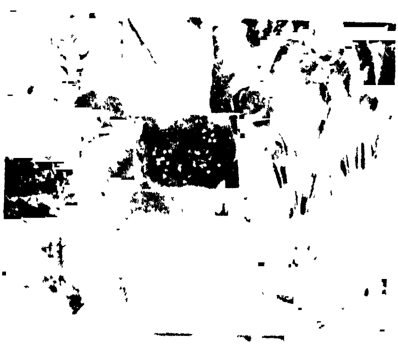


Fig. 4. An artificial box hive, (detached).

A.—The basal piece showing only two of the seven moveable frames. m. fr., moveable frame. br. c., brood comb. f. b., foot board. ent., entrance to the hive.

B.—The middle piece showing only two of the seven frames. m. fr., moveable frame.

C.—The top piece with its ventilations. vn., ventilation.



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STUDIES ON *APIS INDICA*.

EXPLANATION OF THE PLATE.

Photograph 1. An experimental bee hive kept in the Hanging Gardens, Bombay.

Photograph 2. The three pieces of the artificial hive.

Photograph 3. One of the moveable frames, with brood comb, pulled out of the hive.

Photograph 4. A typical comb of *Apis indica*, with the workers.

the hive and bears on its walls small round openings (*vn.*) closed with wire nets for aeration. The wire netting prevents the bees from passing through the opening at the same time offering sufficient ventilation. A hive of this kind could be made for Rs. 5/.

On all the moveable parallel frames the bees construct readily their wax combs. The larger lower combs (Fig. 4 A. *br. c.*) are utilized as brood combs with their supply of brood honey and pollen, while the smaller upper combs are used for the storage of surplus honey.

THE CHROMOSOMES OF POECILOCERA PICTA, FABR.

(A short-horned grasshopper).

By

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Introduction.

Since the beginning of this century male germ cells of Orthoptera, particularly of the short-horned grasshoppers, Acrididae, have furnished very favourable material for chromosomal studies. In Acrididae more than in any other group of insects it has been demonstrated by a host of investigators among whom Dr. McClung ('14) and his associates have been most active that a remarkable constancy of numbers, forms, size and behaviour exists in the chromosomes of a very large number of representatives of this family of short-horned grasshoppers.

Since 1928 one of us, Asana ('28, '30, '31), has been observing a remarkable deviation in chromosome numbers in some representatives of Indian grasshoppers of the sub-family Pyrgomorphinae of the family Acrididae, and a preliminary account of the chromosomes of an Indian species Poecilocera picta is presented herewith.

Material and Method.

The following observations are based on testes derived from nymphs in all stages and adults of P. picta collected from the fields adjoining the Gujarat College, Ahmedabad. Large numbers of these insects are found feeding on the leaves of Calotropis and the common hedge plant, Euphorbia, late in the monsoon. The youngest nymphs appear in the field two times in a year, once in April, and again in October or early November.

Specimens were decapitated or killed by pouring a little xylol on them soon after they were obtained from the field, testes quickly dissected out and subjected to a variety of fixatives, of which Champy's mixture, weak Flemming with reduced glacial acetic acid or just a trace of acetic, and Benda's fluid seemed to be the most favourable for chromosome studies. Sections were cut 10 to 15 micra thick and stained with Heidenhain's iron heamatoxylin.

OBSERVATIONS.

1. *Spermatogonia*: The chromosomes of the spermatogonial metaphase are all rod-shaped, straight or slightly curved (Fig. 1). They arrange themselves radially in the equatorial plate, forming a typical rosette. In sections from well preserved material the homologous mates are easily recognized. The diploid number of chromosomes as seen in the spermatogonia of this species is 19, 9 pairs of which are to be regarded as autosomes, the remaining one is the X-chromosome or the accessory chromosome functioning as a sex determinant. This unpaired accessory can be easily recognized by its rough contour, and it is rather narrower than the autosomes.

According to McClung ('14) the diploid number of chromosomes in several numbers of Orthoptera belonging to the so-called Hippicus-type appears to be 23. While 19 chromosomes as the diploid number have been reported in a few species only, for instance, in Atractomorpha (Machida, '17) and Pamphagus (Granata, '10). As compared with those of the Hippicus-type, the chromosomal complex as seen in Poecilocera, Atractomorpha and one or two other species is devoid of 4 dot-like chromosomes.

2. *Primary spermatocytes*: The chromosomes of the primary spermatocyte metaphase at the first maturation division (S. C.), are 10 in number which are composed of 8 ring-tetrads, 1 rod-tetrad and an accessory or a sex chromosome (Figs. 2-3). The accessory is always situated in the central part of the equatorial plate surrounded by other chromosomes. In this reduction division the autosome tetrads are all divided into two equal halves, each half assuming a V-shape, while the sex chromosome goes undivided to one of the two poles of the spindle slightly in advance of the batch of the V-shaped halves going to the pole towards which the accessory proceeds, as is shown in the tangential view of the spindle (Fig. 4).

3. *Secondary spermatocytes at the metaphase*: As a result of the asymmetrical first maturation division as seen in the above-mentioned primary spermatocytes two kinds of secondary spermatocytes appear at the metaphase of the second maturation division (Figs. 5-6). One group consists of what may be called X-class secondary spermatocytes each of which contains the accessory or sex chromosome besides 9 autosomes, thus having in all 10 chromosomes. In the other group of secondary spermatocytes the accessory or X-chromosome is absent. Cells of this second group contain only 9 autosomes. The chromosomes as seen in this second maturation division are all V-shaped at the metaphase, each V-shaped chromosome consisting of two rods superimposed at their inner ends where the spindle fibres are attached.

Throughout these two maturation divisions the accessory chromo-

some shows a characteristic feature in that it does not get as intensely stained by the dye as the autosomes; it shows comparatively diffuse staining.

We are greatly indebted to Prof. Dr. Kan Oguma to whom we wish to express our sincere appreciation for his great interest and helpful criticism in this study.

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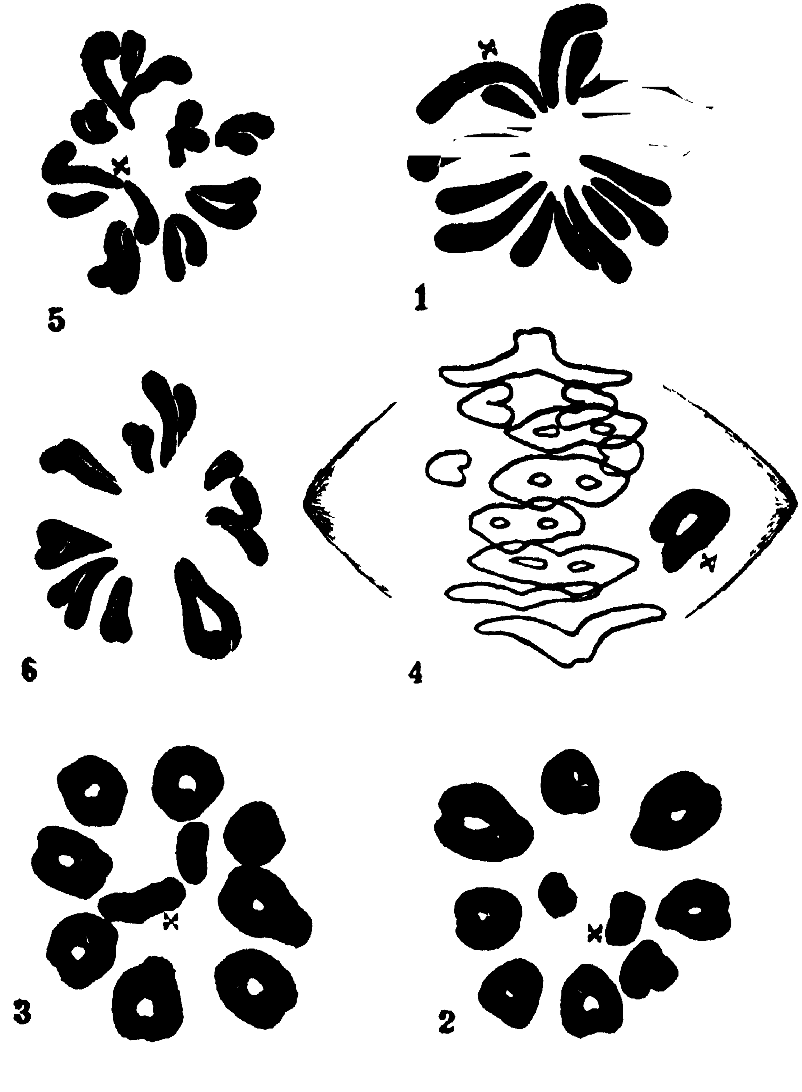

Poecilocera picta (2,000 X).

1, spermatogonial metaphase, 19 chromosomes; 2 3, primary spermatocyte metaphases, 10 tetrads; 4, side view of first division; 5, secondary spermatocyte metaphase, X-class, 10 dyads; 6, the same, no X-class, 9 dyads. X, the sex-chromosome.

THE PROTRUSIBLE VESICLES IN CYRTACANTHA-CRINAE-ACRIDIINAE (Orthoptera).

By

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INTRODUCTION.

The writer discovered these vesicles for the first time in 1929 in Anacridium aegyptium. Anatomical studies since then on other Acridiinae have shown that the vesicles are present in all the specimens

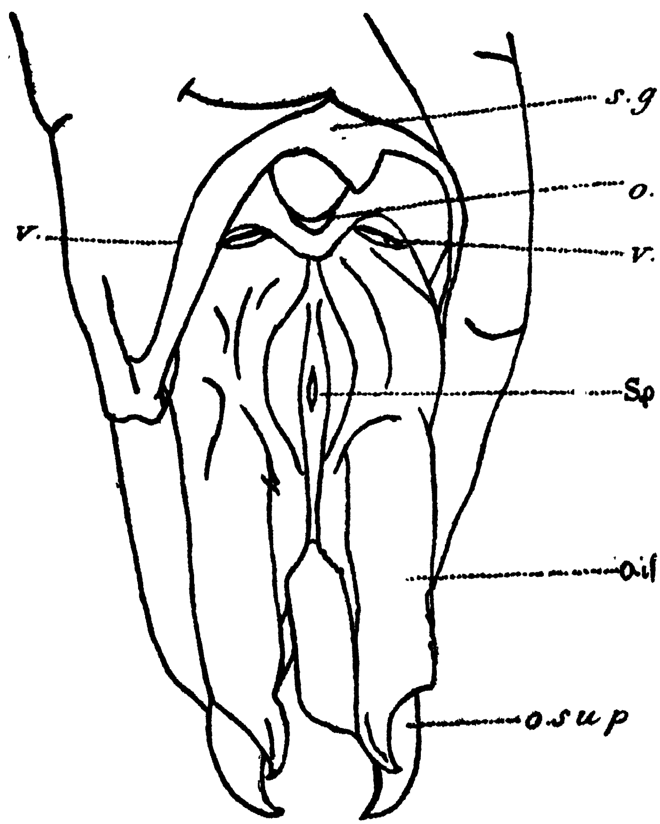

Fig. 1. The posterior end of the abdomen of *Anacridium aegyptium*, female seen from the ventral aspect; the sub-genital plate lifted up and the body tilted to one side to show the orifices of the vesicles (V.) and that of gonopore (O). S. p.=the opening of spermatheca; s. g.=sub-genital plate; o. if=ventral valves of ovipositors; o. sup.=dorsal valves of ovipositors. X 8.

examined and that their presence may form a distinct sub-family character.

The specimens examined are as follows :—

1. *Anacridium aegyptium*, L.
2. *Calliptamus italicus*, L.
3. *Pezotettix giornai*, (Rossi).
4. *Schistocerca paranensis*, Försk.
5. *S. gregaria*, Försk.
6. *Patanga succincta*, L.
7. *Palaciosa khandelensis*, Bolivar.
8. *Podisma sp.*

THE ANATOMY OF THE VESICLES :—

The vesicles in question are situated, one on each side of the gonopore, in the membranous area between the 8th sternite and the base of the ventral valves of the ovipositors. Normally they are hidden from view beneath the sub-genital plate of the 8th sternite (Figs. 1 and 2). Each vesicle has the form of a blind membranous

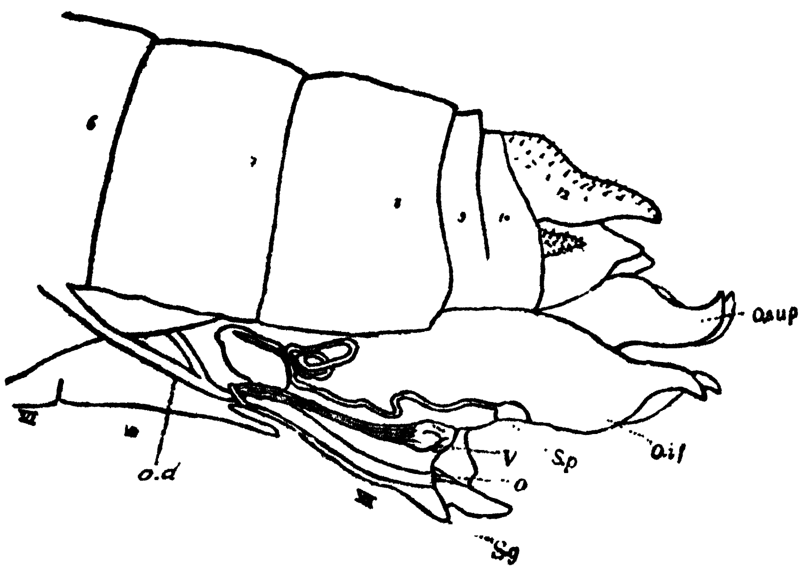

Fig. 2. The same as the figure first seen from lateral aspect, the ventral valves of ovipositors partly dissected to show the opening of spermatheca. o.d. =oviduct. The rest as in the fig. 1. X 8.

pouch projecting into the body cavity on either side of the gonoduct and attached to muscle bands which are inserted into the apodeme of the 8th sternite (Figs. 2 and 3).

The histology of the vesicles :—

A longitudinal section of the wall of the vesicle, under study,

shows the following structures from without inwards :—

1. A thin noncellular layer of chitin.
2. A hypodermal layer and,
3. A very thin layer of the basal membrane.

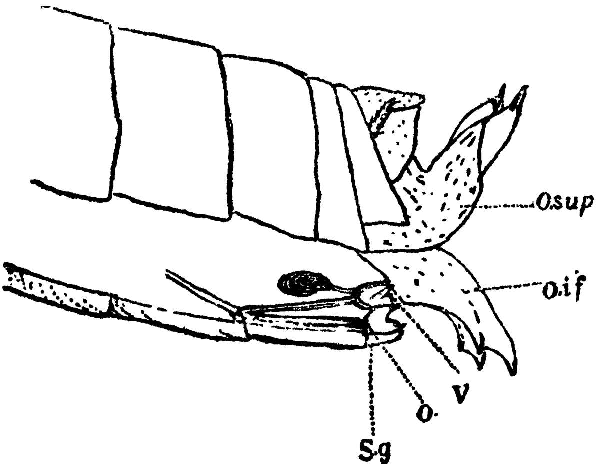

Fig. 3. The posterior extremity of abdomen of *Pezotettix giornai*. Explanations as in the fig. 1. X 10.

The chitinous layer which is formed by the secretion of the hypodermis, is pierced through by a number of fine canalicules or ducteoles with chitinous lining (Fig. 5 C.). The chitinous layer is not of uniform thickness ; towards the bottom of the pouch it is somewhat thinner than elsewhere (Fig. 4).

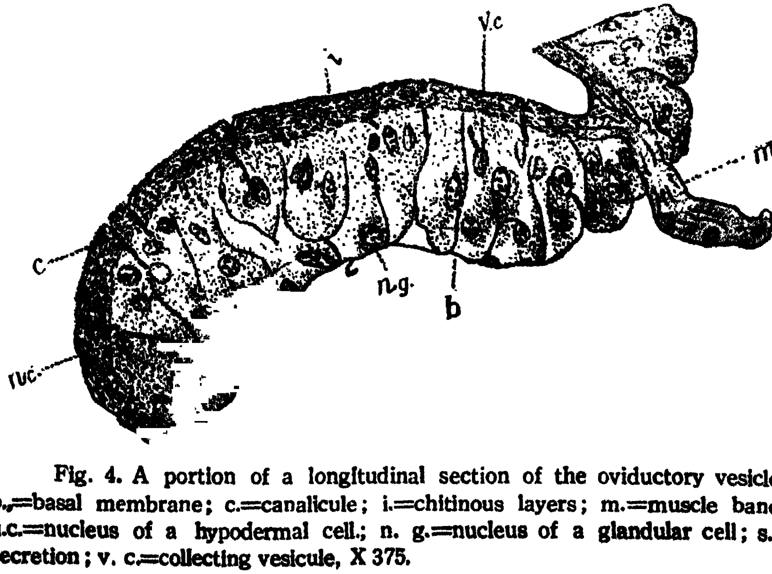

Fig. 4. A portion of a longitudinal section of the oviductory vesicle; b.,=basal membrane; c.=canalicule; i.=chitinous layers; m.=muscle band; n.c.=nucleus of a hypodermal cell.; n. g.=nucleus of a glandular cell; s.= secretion; v. c.=collecting vesicule, X 375.

The hypodermis is composed of elongated cells each containing a large, irregular more or less spherical nucleus with a large number of chromatin granules (Fig. 5 nc.) The cytoplasm of the hypodermal cells shows a reticular appearance after fixation. The basal membrane of these cells is extremely thin.

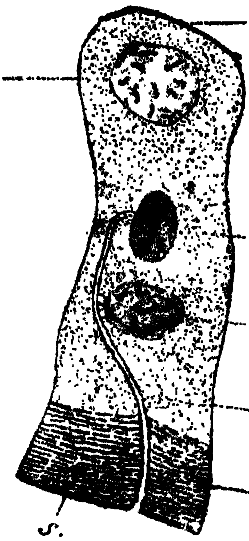

Fig. 5. One of the hypodermal cells surmounted by a glandular cell. Explanations as in the Fig. 4. X 1075.

In between and at the base of the hypodermal cells are found certain typical glandular cells with a large nucleus containing chromatin granules. The cytoplasm of the glandular cells when fixed with common fixatives shows a fine granular structure. Each of these cells contains a form of a small vesicule (Fig. 5 Vc.) which collects the secretory product of the cell and passes it on into the cavity of the pouch along the path of the canalicule (Fig. 5 c)

THE HOMOLOGY OF THE VESICLES :—

Similar type of vesicles—Coxal vesicles—are described by OUDEMANS (1888) in Thysanura. Larvae of *Agelastica alni* and *Melasoma populi* also possess similar vesicles, but in their case the turgidity of the organ is followed by ejection of blood (reflex bleeding).

The vesicles of the type described above are also found in Orthoptera in general. CUENOT (1896) finds a vesicle at the base of the elytra of *Ephipiggar bruneri*. VOSSELER (1903) describes a vesicle situated under the pronotum of *Oedaleus senegalensis* and a similar one near the articulation of coxae in *Eugaster guyoni*. HOLLANDE (1926) also describes certain vesicles of reflex bleeding in *Eugaster spinulosus*.

The vesicles of Acridiinae are, however, associated with the genitalia of the female only. Morphologically they may be considered as homologous with the coxal glands of Thysanura. But then they are found only in Acridiinae. Physiologically they may possibly be similar to the lateral saccules found in the female *Bombyx mori*, where the secretion is ejected at the time of copulation. They are therefore considered as odoriferous organs which attract the male.

Resumé :—

(1) Glandular vesicles are present one on each side of the gonopore of Acridiinae.

(2) The vesicles are protrusible, the movement being controlled by a set of muscle bands attached at one end to the base of the pouch and at the other end to the apodeme of the 8th sternite.

(3) Histological studies indicate the glandular nature of these vesicles.

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STUDIES IN INDIAN PUFFERS OR GLOBE FISHES
II. THE BLOOD VASCULAR SYSTEM OF TETRODON OBLONGUS (Bloch).

By

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The vascular system (Figs. 1, 2, 3, 4, 5, 6 & 7) of Tetrodon oblongus consists of the heart, arteries, veins and capillaries, through which the blood is propelled forward in a definite direction by the

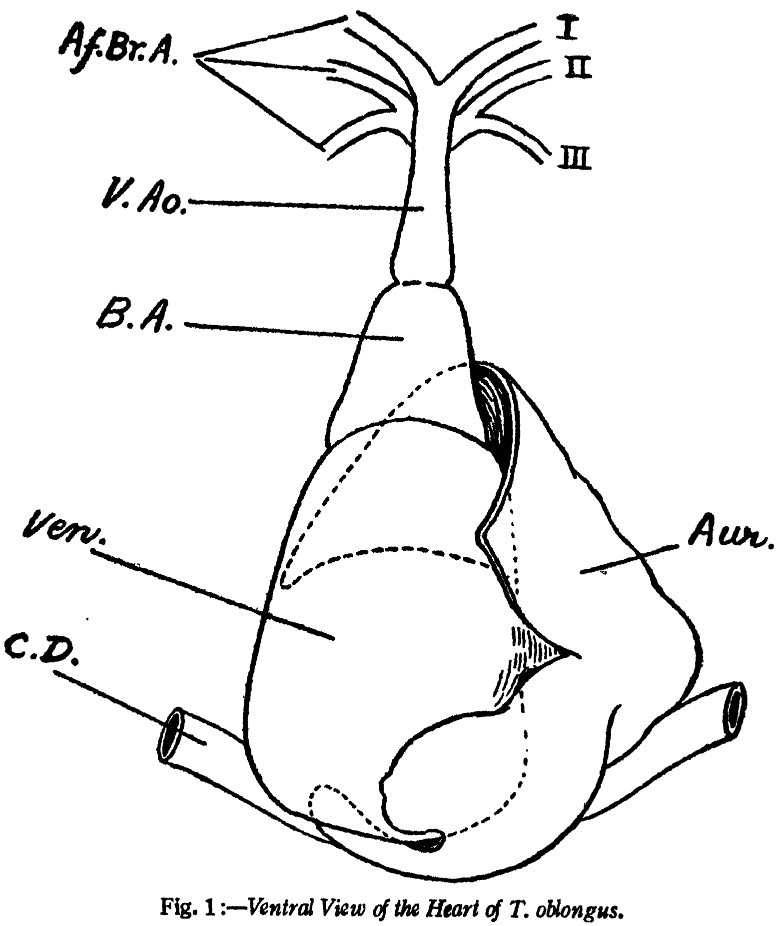

Fig. 1 :—*Ventral View of the Heart of T. oblongus.*

Af. Br. A.—Afferent Branchial Artery; Aur.—Auricle; B. A.—Bulbus Arterious. C. D.—Cuvierian Duct. V. Ao.—Ventral-Aorta. Ven.—Ventricle. I; II; & III.—Afferent Branchial Arteries.

rhythmical contractions of the heart. The course of the blood may diagrammatically be represented as follows :—

Sinus Venosus

Ductus Cuvieri	Auricle
Veins	Ventricle
Capillaries of the Tissues	Bulbus Arteriosus
Arteries to the body	Ventral Aorta
Epibranchial arteries	
Efferent branchial arteries	Afferent branchial arteries

Capillaries of the gills

The circulation of blood can be described under different following heads :—

1. *Heart* :—The heart (Figs. 1 & 2) in Tetrodon oblongus consists of the sinus venosus, the auricle and the ventricle and is surrounded by the thin pericardium. The heart nearly fills the pericadial cavity which is closed off from the abdominal coelom by a fibrous transverse septum.

Sinus venousus :—The sinus venosus (Fig. 4 Sin. V.) is a thin walled transversely elongated chamber placed at the base of the pericardial cavity. The large veins opening into it are the paired cuvierian ducts (into which open vessels from the anterior as well as posterior regions of the body), the paired subclavian and lateral veins, and the unpaired hepatic and inferior jugular veins. The sinus venosus together with the cuvierian ducts forms a horse-shoe shaped structure with the ends pointing dorsalward. It encircles the oesophagus ventrally and laterally.

The sinus venosus communicates anteriorly with the auricle through the sinu-auricular aperture (Fig. 2 Si. Au. Ap.), situated in the middle of its ventral wall. This opening is guarded by a valve (Fig. 2 Si. Au. V.), consisting of two membranous flaps (lips) anterior and posterior in position. This valve prevents the backward flow of blood from the auricle into the sinus venosus during the contraction of the former.

Auricle :—The auricle (Aur.) is a very irregularly shaped structure. It lies on the left side of the ventricle and extends slightly on its anterior and posterior sides and encircles it on both the ventral and dorsal sides. The wall of the auricle is thicker than that of the sinus venosus and is strengthened internally, especially on its dorsal and ventral portions by interlacing muscle bands, the musculi pectinati

(Fig. 3 M. P.). It is separated from the ventricle by short horizontal auriculo-ventricular constriction. In the latter is situated the auriculo-ventricular orifice (Fig. 2 Au. Ve. Ap.) through which the auricle opens into the ventricle. It is guarded by a pair of vertical semilunar pocket-shaped valves, one anterior and the other posterior (Fig. 2 Au. Ve. V.). They are membranous flaps which project into

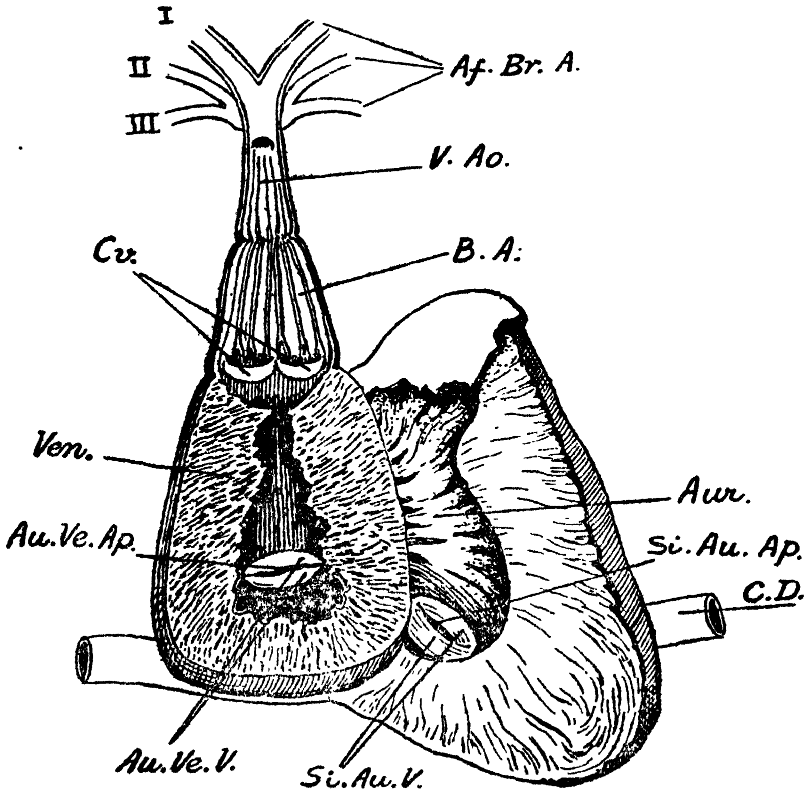

Fig. 2.—*The Heart of T. oblongus dissected from the ventral surface.*

Au. Ve. Ap.—Auriculo-Ventricular Aperture; Au. Ve. V.—Semilunar Pocket-shaped valves.; Cv.—Semilunar Valves; Si. Au. Ap.—Sinuauricular Aperture.; Si. Au. V.—Sinu-auricular Valve. Remaining letters same as in Fig. 1.

the cavity of the ventricle, with the cavities of the pockets facing the ventricle. The mechanism of this kind of valves consists of the pockets being swollen out by the blood flowing into them and thereby closing the orifice.

Ventricle :—The ventricle (Ven.) is antero-posteriorly enlongated cylindrical structure, situated somewhat ventral to the auricle. Its posterior portion as already mentioned, is partly enclosed by the auricle. The walls of the ventricle are very thick and muscular and

are produced internally into ridges—the columnae carnae (Fig. 3 Col. C.). The latter reduce its lumen to a considerable extent and give the ventricle a spongy texture. The structure that follows the ventricle is the Bulbus Arteriosus which is nothing but a greatly dilated basal end of the ventral aorta. Between the ventricle and the bulbus arteriosus there is a deep constriction or furrow which appears to indicate the remains of the conus, since in this region there is a pair of semilunar valves (Fig. 2 Cv.) located one above the other dorsoventrally. They guard the opening of the ventricle into the bulbus. They are pocket-shaped and have semilunar edges. Their cavities point towards the bulbus arteriosus.

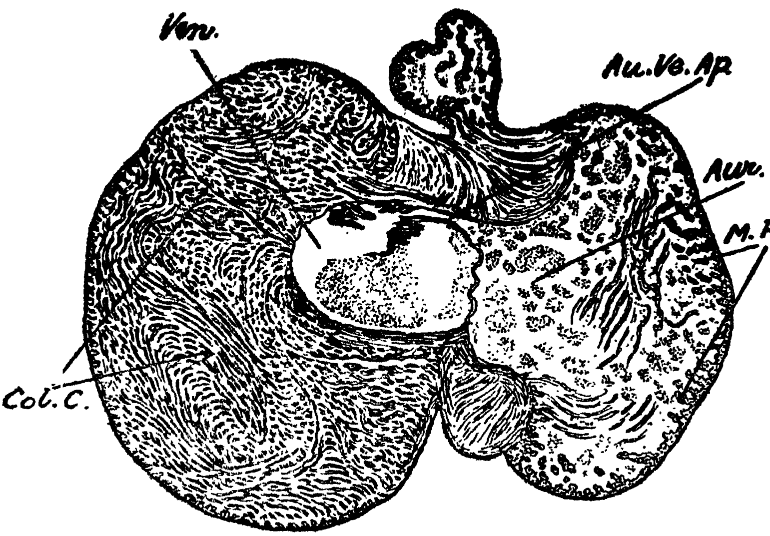

Fig. 3 :—*Transverse Section of the Heart of T. oblongus passing through the Auricle and Ventricle.*

Col. C.—Columnae Carnae ; M. P.—Musculi Pectinati. Remaining letters same as in Figs. 1 & 2.

Bulbus arteriosus:—The structure of the heart of a higher Teleost deviates generally from that of a lower Teleost and other fishes like the Elasmobranchs as far as the region of the conus is concerned. The lower Teleostomes (such as the Chondrostei, Polypterini and Lepidosteoidei) possess a well developed muscular and contractile conus which is a continuation of the distal end of the ventricle. In the higher Teleostomes (such as the Teleostei) on the other hand, the conus is reduced and is replaced wholly or partially by a non-contractile and non-muscular structure called " The bulbus Arteriosus " (B. A.). Thus the bulbus arterious does not constitute any part of the heart but it is simply a swollen proximal or basal part of the ventral aorta. The latter is greatly swollen at its origin from

the ventricle and its internal surface is produced into longitudinal folds. Its walls as well as the folds are composed of the fibrous connective tissue without muscle strands.

Ventral Aorta :—The bulbus arteriosus is followed by the distal part of the ventral aorta (V. Ao.) which runs along the ventral surface of the pharynx and between the ventral extremities of the gill arches. It is a non-contractile and tubular structure and its walls are composed of fibrous connective tissue. It gives rise to three afferent branchial arteries (Af. Br. A.) on each side.

The Afferent Branchial Arteries :—The first pair of the afferent branchial arteries is formed by the bifurcation of the ventral aorta itself and supplies blood to the first pair of gills. Each of them runs along the outer grooved surface of the first branchial arch, supplying blood through numerous branches along its whole length to the anterior and posterior gill lamellæ of the first holobranch. The second and third afferent branchial arteries of each side seem to arise from the common vessel arising from the ventral aorta at a little distance behind the first. This common vessel is divided internally by a fine septum into two branches almost at its origin but externally it appears to be continued as one for an appreciable distance where the two afferent arteries diverge from each other. The second and third afferent arteries of each side run almost parallel with the first of that side along the grooved surfaces of the second and third branchial arches respectively.

The function of the heart is to pump the blood to the gills. This pumping of the blood is effected by the rhythmical and successive contractions of the heart. These contractions are effected by muscle strands of the muscular tissue of which the heart is made. The contraction of the different parts of the heart takes place in a regular order ; first the sinus, then the auricle and ventricle and finally it ends in the bulbus or ventral aorta. When the sinus venosus contracts, the blood, brought to it by the veins coming from different parts of the body, is forced forward into the auricle through the sinu-auricular aperture. But the blood is prevented from running backward into the ductus cuvier since the latter, being always full, is under a higher pressure than what is obtained in the auricle. The two membranous flaps which form the sinu-auricular valve, prevent the backward flow of the blood from the auricle into the sinus when the former contracts in its turn and drives the blood into the ventricle. The two semilunar pocket-shaped valves in the ventricle act likewise and prevent blood from flowing back into the auricle when the ventricle contracts. During the contraction of the ventricle, the blood passes into the bulbus arteriosus and thence into the ventral aorta. There is a pair of semilunar valves at the opening of the ventricle into the

bulbus arteriosus and any return of the blood into the ventricle is made impossible by the presence of these valves. The blood then passes into the three pairs of afferent branchial arteries in order of their origin and is taken ultimately into a great number of lamellar capillaries of the gills where the oxygenation of the blood takes place.

The Efferent Branchial Arteries :—The aerated blood from the several gill lamellæ is collected by a set of efferent capillaries into three pairs of blood vessels called " the efferent branchial arteries " (Fig. 4 Ef. Br. A.) corresponding to the three afferent branchials. There are only three such arteries on each side (since the fourth efferent branchial artery has disappeared along with the disappearance of the fourth gill). It should be noted here that the blood from the two demibranchs of each branchial arch i.e., from a single holobranch is conveyed to the lateral dorsal aorta of each side by single efferent vessel unlike that of the Dogfish in which a loop is formed in the gill region. Each efferent branchial artery is continued dorsally towards the lateral dorsal aorta (L. Ao.) of its side as the epibranchial artery (E. Br. A.). The three epibranchials of each side form the lateral dorsal aorta of that side. The paired lateral aortae thus formed unite posteriorly on the dorsal side of the œsophagus and form the dorsal aorta (D. A.). Anteriorly they run towards the base of skull as the common carotid arteries which will be described in connection with the head arteries.

The Arteries of the Head (Fig. 4) :—The common carotid artery (C. Car. A.) which is the anterior continuation of the lateral aorta divides into the external and internal carotids.

The external carotid (Ex. Car.) is termed as " Orbitonasal " by Allen, Nils Rosen and other authors. It runs forward along the ventral surface of the skull and extends right up to the anterior end of the head. On its way it gives off several branches supplying the eyes, eye-muscles, nostrils etc. While the internal carotid (I. Car.) after running for a short distance enters the parasphenoid and meets its fellow from the other side and thus forms the "Circulus Cephalicus", the characteristic structure of the Teleosts (Cir. C.).

A pair of arteries is given off both anteriorly and posteriorly from the circulus cephalicus at the place of the union of the two internal carotids. The anterior pair forms the Optic arteries (Opt. A.) and the posterior, the Cerebral arteries (Cer. A.). The Optic arteries have a very short common root since they soon diverge out from each other. Each of them, then, passes out towards the eye of its side along the corresponding optic nerve and enters the retina along with the nerve. While the Cerebral arteries arise like the optic arteries, but on the opposite side from the circulus cephalicus. They enter the cranial cavity through the parasphenoid and then they separate out immediately after their entrance into the right and left cerebral

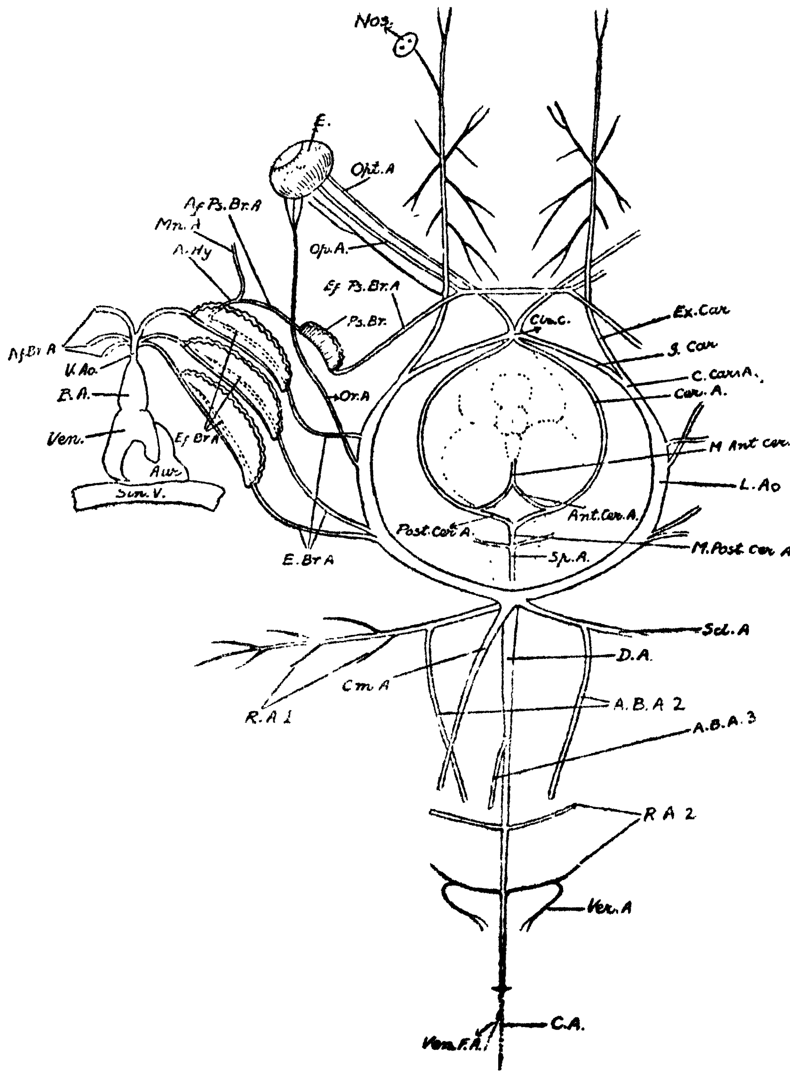

Fig. 4 :—*Arterial System of T. oblongus.*

A. B. A. 2—Artery to the Air Bladder from the Subclavian artery; A. B. A. 3—Artery to the Air Bladder from the Dorsal Aorta; A. Hy.—Hyoidean Artery; Af. Br. A.—Afferent Branchial Artery; Af. Ps. Br. A.—Afferent Pseudo-branchial Artery; Ant. Cer. A.—Anterior Cerebral Artery; Aur.—Auricle; B. A.—Bulbus Arteriosus; C. A.—Caudal Artery; C. Car. A.—Common Carotid Artery; Cer. A—Cerebral Artery; Cir. C.—Circulus Cephalicus; Cm. A.—Coeliaco Mesenteric Artery; D. A.—Dorsal Aorta; E.—Eye; E. Br. A.—Epibranchial Artery; Ef. Br. A.—Efferent Branchial Artery; Ef. Ps. Br. A.—Efferent Pseudo-branchial Artery; Ex Car.—External Carotid Artery; I. Car.—Internal Carotid Artery; L. Ao.—Lateral Dorsal Aorta; M. Ant. Cer. A.—Median Anterior Cerebral Artery. M. Post. Cer. A.—Median Posterior Cerebral Artery; Mn. A.—Mandibular Artery; Nos.—Nostril; Op. A.—Ophthalmic Artery; Opt. A.—Optic Artery; Or. A.—Orbital Artery; Post. Cer. A.—Posterior Cerebral Artery; Ps. Br.—*Pseudobranch*; R. A. 1.—Arteries to the Kidney from the Subclavian Artery; R. A. 2.—Arteries to the Kidney directly from the Dorsal Aorta; Scl. A.—Subclavian Artery; Sin. V.—Sinus Venosus; Sp. A.—Spinalis Artery; V. Ao.—Ventral Aorta; Ven.—Ventricle; Ven. F. A.—Artery to the Ventral Fin; Ver. A.—Vertebral Artery.

arteries. Each of them curves out by the side of the pituitary body and forms a sort of a semicircular loop within the cranial cavity. Posteriorly the two loops approach each other in a mid-ventral line between the optic lobes, where each of them again divides into two branches forming the anterior and posterior cerebral arteries (Ant. Cer. A; Post. Cer A.). The anterior cerebrals after a short course unite with each other beneath the optic lobes and form the combined median anterior cerebral artery (M. Ant. Cer. A.). The latter runs forward along the ventral portion of the brain anterior to the cerebellum and thereby supplies blood to this part of the brain. The posterior cerebrals likewise meet each other and form the combined median posterior cerebral artery (M. Post. Cer. A.), which proceeds towards the posterior region along the ventral surface of the brain. The combined median posterior cerebral artery gives out a small pair, one on either side beneath the medulla oblongata. It supplies blood to the fifth, seventh, eighth and ninth cranial nerves and also to the auditory organ. The median artery is then continued behind as the spinalis or basilaris (Sp. A.) artery which runs along the ventral surface of the spinal cord throughout its length.

The Orbital artery (Or. A.) arises on each side of the lateral aorta a little behind the opening of the first epibranchial artery into the same. It is known as orbital artery (Goodrich) or external carotid (Nils Rosen). It runs forward towards the orbit dorsal to the pseudobranch and supplies blood to the region surrounding the eye.

The Pseudobranchial or Hyoidean artery (A. Hy.) is a fairly large vessel arising on each side from the ventral end of the first efferent branchial. It is called the "Hyoidean or Pseudobranchial artery" which on leaving the branchial arch gives rise to a small branch called Mandibular artery (Mn. A.). The latter supplies blood to the mandibular and to the opercular regions. The main hyoidean trunk then turns round dorsally and runs along the internal surface of the operculum as the "Afferent Pseudobranchial artery" (Af. Ps. Br. A.). After reaching the pseudobranch it breaks up into several capillaries in the filaments of that structure. The blood from the pseudobranch is again collected by the efferent pseudobranchial capillaries. All these unite to form the "Efferent Pseudobranchial artery" (Ef. Ps. Br. A.) which after crossing over the external carotid divides into two branches. One of them is known the Ophthalmic artery (Op. A.) and the other running inward, meets its fellow from the other side above the parasphenoid. The ophthalmic of each side proceeds towards the eye along the optic nerve of its side and parallel with the optic artery already described. It finally perforates the sclerotic coat and supplies blood to the choroid gland of the eye.

Thus it will be seen from the above description that the pseudobranch is supplied with arterial blood unlike the other gills. It, therefore, appears that it has lost its original respiratory function though its morphological structure is almost similar to that of a demibranch of an ordinary gill. The function of the pseudobranch is not yet ascertained. Joh. Muller (6) suggested that the pseudobranch is a gland furnishing an internal secretion, and that the object of the included capillary system of the pseudobranch is to equalise the intraoptical pressure by smoothing down the pulsation of the heart. According to Cole and Johnstone (6) there is no evidence of the elaboration of any internal secretion and the blood in the ophthalmic artery has already passed through the branchial capillaries before reaching the pseudobranch.

The Hypobranchial Arteries (Fig. 5):—They consist of small vessels, arising from the ventral ends of the three pairs of efferent branchial arteries. The prominent of them is a small commissural vessel (Com. A. 2.), arising from the ventral end of the second efferent branchial artery. It unites with its fellow of the other side below the ventral aorta and the combined vessel thus formed is called the " Median Hypobranchial Artery " (Md. Hy. Br. A.). The latter runs down for some distance in a vertical direction through the sterno-hyoid muscles and then turns behind towards the posterior side. It gives off a single " Sternohyoid " artery (St. A.) to the sternohyoid muscles while passing through them. Then the median hypobranchial artery is continued towards the posterior end and it gives off a pair of lateral branches at the anterior end of the pericardial cavity. Each of the laterals may be called as the " Pericardial " artery (Peri. A.) which runs on each side along the outer margin of the pericardial cavity and finally disappears in the muscles of the pectoral girdle. On its way it gives off several smaller branches, supplying blood to the heart, the pericardium, the air-sac and to the pectoral muscles. Behind the pericardials, the median hypobranchial artery becomes small and supplies blood to the ventral longitudinal muscles of the air-sac and to the air-sac itself (A. S. A.). Each commissural from the second efferent branchial artery gives off in addition a small branch towards the anterior side before joining its fellow from the other side. This small Buccal Artery (Bu. A.) runs forward and supplies blood to the muscles on the ventral wall of the buccal cavity.

Similarly there arises on each side a commissural vessel from the ventral ends of the first and third efferent branchial arteries. The commissural from the first (Com. A. 1.) is small and divides into two branches at some distance from its origin. The anterior of the two runs in front and the posterior one joins the commissural from

the second efferent branchial artery. The commissural from the third (Com. A. 3) likewise divides into two branches. The anterior of them runs forward and opens into the commissural from the second.

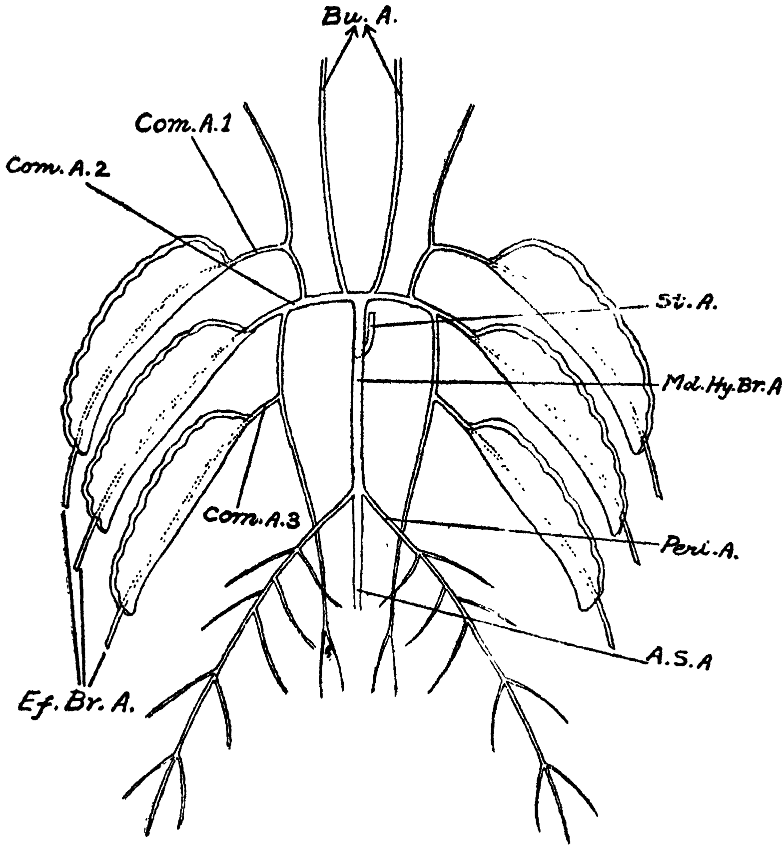

Fig 5 :—*The Hypobranchial Arteries of T. oblongus.*

A. S. A.—Artery to the Air Sac; Bu. A.—Buccal Artery; Com. A. 1.—Com. A. 2. and Com. A. 3.—Commissural Vessels from the First, Second & Third Efferent Branchial Arteries respectively; Ef. Br. A.—Efferent Branchial Artery; Md. Hy. Br. A.—Median Hypobranchial Artery; Peri. A.—Pericardial Artery; St. A.—Sternohyoid Artery.

The posterior branch of the same runs behind and breaks into smaller vessels below the oesophagus. It supplies blood to the dorsal region of the heart, and to the pharyngeal and oesophageal regions.

The Dorsal Aorta and its Branches :—The dorsal aorta (Fig. 4) gives out several branches which are described below.

(1) *The Subclavian Arteries*:—A pair of large vessels arises from the dorsal aorta at its very beginning. They are called the " Subclavian arteries " (Scl. A.) supplying the paired pectoral fins. Immediately after their origin they proceed out towards the body-wall

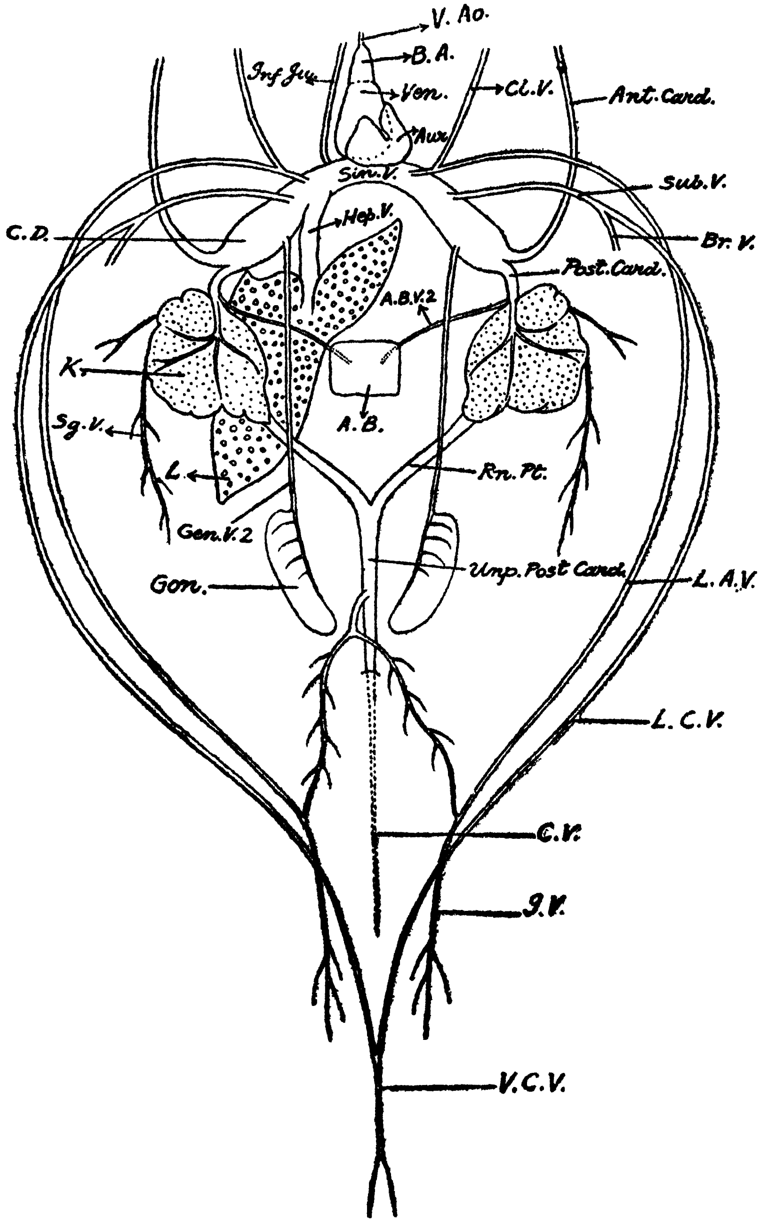

Fig. 7 :—*Venous System of T. Oblongus.*

A. B.—Air Bladder; A. B. V. 2—Vein from the Air Bladder opening into the Posterior Cardinal Vein; Ant. Card.=Anterior Cardinal Vein; Aur= Auricle; B. A.=Bulbus Arteriosus; Br. V.=Brachial Vein; C. D.=Cuvierian Duct; C. V.=Caudal Vein; Cl. V.=Clavicular Vein; Gen. V. 2=Genital Vein opening into the Cuvierian Duct; Gon.=Gonad; Hep. V.=Hepatic Vein; I. V.= Iliac Vein; Inf. Ju.=Inferior Jugular Vein; K.=Kidney; L.=Liver; L.A.V.= Lateral Abdominal Vein; L.C.V.=Lateral Cutaneous Vein; Post. Card.= Posterior Cardinal Vein; Rn. Pt.=Renal Portal Vein; Sg. V.=Segmental Vein; Sin. V.=Sinus Venosus; Sub. V.=Subclavian Vein; Unp. Post. Card.=Unpaired Posterior Cardinal Vein; V. C. V.=Ventral Caudal Vein; Ven.=Ventricle.

(B) Veins in the body-wall.

(a) The Lateral Abdominals.

(b) The Lateral Cutaneous.

I. All the blood from the head region is returned to the heart by the large paired anterior cardinals, unpaired inferior Jugular and by the paired clavicular veins coming from the clavicular muscles.

(a) *The Anterior Cardinals*:—The paired anterior cardinals (Fig. 7 Ant. Card.) are large thin-walled vessels which drain the blood from the head, eyes, brain, branchial regions etc. They start from the anterior portion of the head and are joined on their way by smaller vessels from the orbito-nasal and branchial regions. They, then, run towards the heart along the ventral surface of the skull and dorsal to the branchial arches. The anterior and posterior cardinals of each side open side by side into the wide transverse vessel, the "Cuvierian duct" (C. D.). The latter is continued into the sinus venosus.

(b) *The Inferior-Jugular*:—The unpaired inferior jugular vein (Inf. Ju.) originates from the ventral margin of the branchial arches and runs above the ventral aorta for a short distance. It then bends outside and proceeds towards the sinus venosus by the side of the heart. It opens into the right side of the sinus venosus.

(c) *The Clavicular Veins*:—They consist of two slender vessels (Cl. V.) arising from the antero-lateral side of the skull and from the clavicular muscles. They proceed towards the sinus venosus along the ventral region of the gills. Each of them collects blood from the clavicular muscles and finally joins the lateral abdominal vein (to be described subsequently) of its side.

II. The Veins that drain off the blood from the region behind the heart can be described under two heads as mentioned in the table given above.

(A) The veins coming from the abdominal cavity consist of five principal vessels as described below.

(a) *The Posterior Cardinals*:—The Posterior Cardinal veins (Post. Card.) consist of two wide but very short vessels owing to the shifting of the kidneys towards the anterior end of the abdominal cavity. Each of them commences in the compact kidney of its side and then approaches the anterior cardinal of the same side in the region of the heart. However it opens separately into the cuvierian duct as mentioned above. In addition to the blood from the kidney, the posterior cardinal receives venous blood from the air bladder (A. B. V. 2). A small vein starts on each side from the dorsal wall of the air bladder and after running outward towards the region of the kidney, it empties its contents into the lumen of the posterior cardinal vein.

(b) *The Renal Portal System* :—The caudal vein (C. V.) from the tail runs towards the anterior side through the haemal canal, immediately beneath the caudal artery. It, then, emerges into the abdominal cavity and runs as a single vessel for a short distance. This undivided portion of the caudal vein may be called as the "Unpaired Posterior Cardinal" (Unp. Post. Card.) vein. It is joined on its way by a single vein, formed by the union of two vessels one from each side. The latter are the inner branches of the iliac vein (I. V.). It then divides into the right and left renal portal veins (Rn. Pt.) at some distance behind the air bladder. Each of the branches curves out and proceeds towards the kidney of its side and enters the posterior lobe of the same. It breaks into several smaller branches in that organ. The kidney also receives an additional supply of venous blood from the muscles of the trunk through several segmental veins (Sg. V.). Finally the blood from the kidney is drained off by the posterior cardinal and thence to the cuvierian duct.

(c) *The Hepatic Portal System* (Fig. 6):—The blood from the different parts of the alimentary canal, also a small portion from the gonads (Gen. V. 1.), the urinary bladder and the two ureters, together with a small portion of blood from caudal vein (B. C. V.) and the blood from the ventral region of the air bladder (A. B. V. 1), is collected by a series of smaller veins constituting the Hepatic Portal system. These several veins join each other as they run towards the liver and thereby give rise to a principal vein called "The Hepatic Portal Vein" (Hep. Pt.). The latter runs towards the liver and finally discharges its contents into it. It should however be noted that the hepatic portal vein does not enter into the liver by a single trunk but it divides again into a small number of branches before entering into the liver. They, then, enter the liver independently and break into numerous capillaries in the interior of that organ.

The blood from the liver is recollected by a number of small veins which ultimately unite into a short, wide and unpaired vein called the "Hepatic Vein" (Fig. 7 Hep. V.). The latter opens directly into the sinus venosus.

(d) *The Genitals* :—A stout vein (Fig. 7 Gen. V. 2) starts from each gonad (either testis or ovary) and runs forward towards the heart along the ventral surface of the air-bladder. It finally opens directly into the cuvierian duct of its side. It should be mentioned here that in a few specimens it was found that the two genital veins joined each other and then the single vessel, thus formed, opened into the right cuvierian duct.

(e) *The Air-bladder Vein*:—A small vein (Fig. 7 A. B. V. 2) starts on each side from the dorsal wall of the air bladder and after running outward towards the region of the kidney, it empties its con-

tents into the lumen of the posterior cardinal vein of its side. It may be noted here that a portion of the venous blood from the ventral region of the air bladder is collected by a single slender vessel. The latter opens (as described above) into the hepatic portal vein on its way towards the liver (Fig. 6 A. B. V. 1.).

(B) The Veins running along the body wall consist of two paired loop-like vessels as described below :—

(a) *The Lateral Abdominals* :—These paired veins arise from the post-cloacal myotomes, on the ventral region of the tail by the side of the ventral fin. Each of them is formed by the union of several smaller vessels coming from the muscles of the surrounding area of the ventral fin and some from the ventral fin itself. They, thus, give rise to a single vessel on each side of the ventral fin. It seems to correspond to the Iliac vein (I. V.) of the Dogfish. Each of them proceeds forward and divides into two branches as soon as it enters the abdominal cavity. The inner of the two receives several segmental veins from the precaudal myotomes and from the cloacal region. It, then, joins its fellow of the opposite side and the common vessel thus formed opens into the unpaired posterior cardial vein as described above. The outer branch on the other hand continues forward as the well-known "Lateral Abdominal Vein ", on each side (Fig 7. L. A. V.). It runs forward along the latero-ventral side of the body, immediately external to the peritoneum and is more or less embedded in the ventral longitudinal muscles. On its way towards the heart it receives several branches from the trunk muscles. It turns dorsalwards in the pectoral region and then receives a branch from the clavicular muscles as described above. The common vessel thus formed turns again towards the posterior side and soon enters the sinus venosus.

(b) *The Lateral Cutaneous* :—In the mid-ventral region of the tail behind the ventral fin, a vein is formed by the union of two smaller vessels. The single vein so formed may be called for convenience sake " The Ventral Caudal Vein" (V. C. V.) as distinguished from the other caudal vein already described. It runs along the mid-ventral line as far as the ventral fin, where it divides into two branches one running on each side of the fin. It, then, proceeds along the lateral bodywall as the " Lateral Cutaneous Vein" (L. C. V.) below the skin and running almost parallel with the lateral abdominal vein mentioned above. On each side it runs as far as the pectoral region where it joins anteriorly with the Brachial vein (Br. V.) of its side. The common vein thus formed, carrying blood both from the pectoral girdle and from the lateral cutaneous vein may now be called the " Sub-Clavian Vein" (Sub. V.). The latter enters finally into the sinus venosus.

Thus it will be seen that certain portion of the venous blood from caudal region reaches the heart directly without the intervention of

either the renal portal or hepatic portal systems; whereas the remaining main portion of blood has to pass through one of the two portal systems.

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TWO NEW SPECIES OF THE GENUS *DIPLOTRIÆNA* (NEMATODA) PARASITIC IN THE COMMON INDIAN MYNA

(*Acridotheres Tristis Tristis*).

By

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The parasitic worms described in this paper were collected from the body-cavity of the Myna on two occasions. A study of the structure of these worms revealed the presence of two distinct species in the lot.

DIPLOTRIAENA ACRIDOTHEREI N. SP.

The worms belonging to this species are long and white in colour. The males measure 35 mm.–52 mm. in length and have a maximum width of 0·487 mm. Females are much longer than the males and are 118 mm.–125 mm. long with a maximum breadth of 0·7 mm.–1·2 mm. The cuticle of the body appears to be unstriated in both the sexes. The worms taper towards the extremeties, the anterior end being somewhat narrower than the posterior one. The trident measures 0·127 mm.–0·154 mm. in the male and 0·154 mm.–0·245 mm. in the female. Its anterior end is blunt. The oesophagus can be seen through the body-wall, in all the specimens, with the naked eye. It is divided into two parts—a short anterior and a very long posterior one. The posterior portion of the oesophagus, in all the specimens, appears black under the microscope. The length of the entire oesophagus is 8·61 mm.–8·691 mm. in the male and 9·17 mm.–11·072 mm. in the female. The short anterior part of the oesophagus is 0·21 mm.—0·227 mm. long in the male and 0·21 mm.–0·272 mm. in the female. The nerve ring is situated at 0·209 mm.–0·227 mm. from the anterior end in the male and 0·2 mm.–0·209 mm. from the same end in the female. The tail of the male measures about 0·1 mm. in length and is truncated. It is somewhat compressed dorsoventally and expanded to some extent laterally in the cloacal region. The tail of the female is round and measures 0·290 mm.–0·372 mm. in length.

There are eleven pairs of caudal papillae in the male. Two pairs are preanal and the remaining ones postanal. The left papilla of the second preanal pair is, in some specimens, displaced and is situated by

the side of the anal aperture. Of the eleven pairs, five are situated on the margin of the tail. The spicules are unequal and dissimilar. The right spicule which measures 0·55 mm.-0·61 mm. is spirally coiled and is the smaller of the two. The left spicule is straight, much longer and varies from 1·7 mm.–2·51 mm. in length.

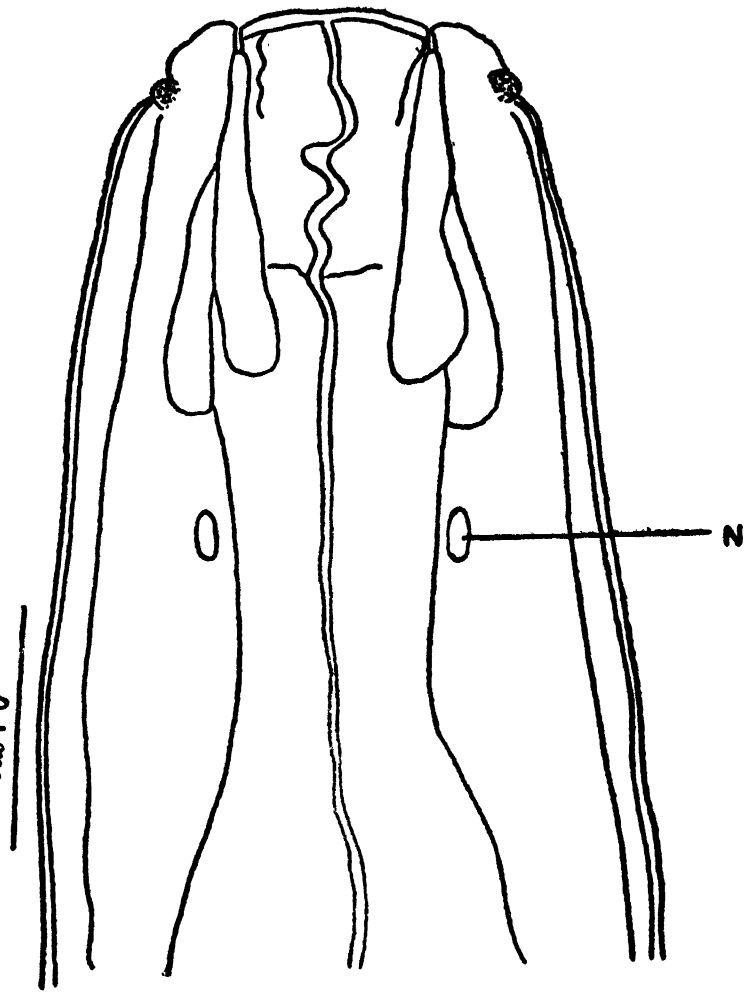

Fig. 1
Diplotriacna acridotherei
Dorsal view of the anterior end of the male. N—Nerva ring.

In the female the vulva is situated at a distance of 0·454 mm.–0·609 mm. from the anterior end. The vagina is muscular and gradually dilates as it runs posteriorly, the point of bifurcation being situated at a distance of about 2·90 mm. from the vulva in a specimen

measuring 125 mm. The eggs are thick-shelled and measure 0·056 mm.–0·059 mm.×0·035 mm.–0·04 mm.

Host—Myna (*Acridotheres tristis tristis*)
Habitat—Body cavity.
Locality—Nagpur (C. P.)

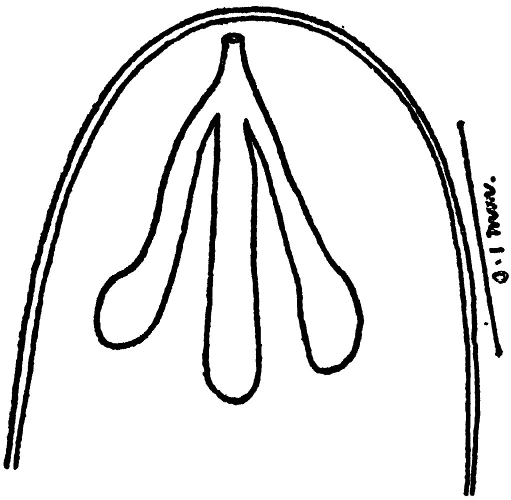

Fig. 2
Diplotriaena acridotherei
Laterval view of the anterior end of the male.

DIPLOTRIAENA NAGPURENSIS N. SP.

A single male worm of this species was found among the worms belonging to the species *D. acridotehrei.* It could easily be marked out from the rest on account of its concave anterior end and the projecting tridents.

The total length of the worm is 33·95 mm. with a maximum thickness of about 0·591 mm. The tridents measure 0·165 mm. Their anterior end is truncated and projects beyond the cuticle of the anterior end of the worm. In the dorsal view the anterior extremity shows a forwardly directed concavity with the tridents on each side of it. The oesophagus is very long and as usual is divided into a short anterior portion, measuring 0·272 mm. and a much larger posterior one with a length of 7·178 mm. The nerve ring is situa-

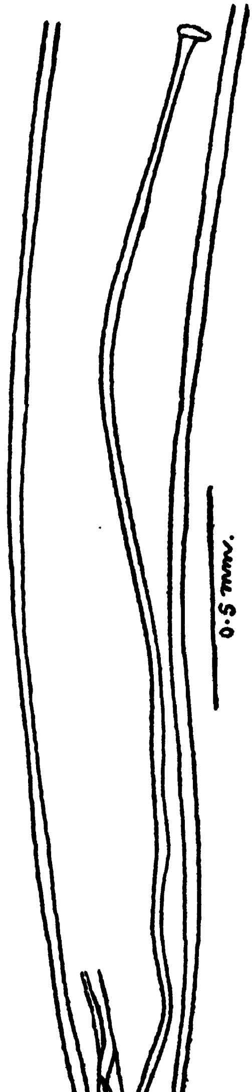

Fig. 3
Diplotriaena acridothe·ei.
Posterior end of the male to show the spicules. Ventral view.

ted at 0·2 mm. from the anterior end and encircles the first portion of the oesophagus.

The posterior end appears round in lateral view, but when seen from the ventral side, it is truncated. No caudal papillae could be

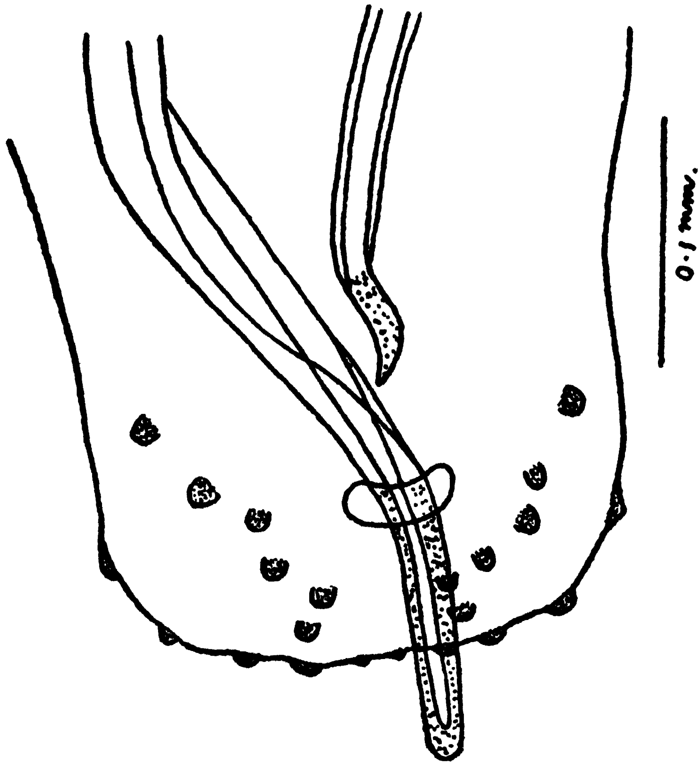

Fig. 4
Diplotriaena acridotherci
Tail of the male under higher magnification showing the caudal papillae and the ends of Spicules. Ventral view.

made out. The cuticle of the postanal as well as some portion of the preanal region, is granular. The cloaca and the lips of the anal aperture are supplied with muscles which are inserted on cuticular thickenings. The appearance presented by the tail is like a network of muscles with granular interstices. The spicules are unequal and dissimilar. The right one is spirally coiled and measures 0·5 mm. while the left is 2·1 mm. in length.

This worm resembles *D. pungens* (Schneider, 1866) and *D. urocissae* Maplestone, 1931, in certain characters. However, it possesses others which distinguish it from both these species. In

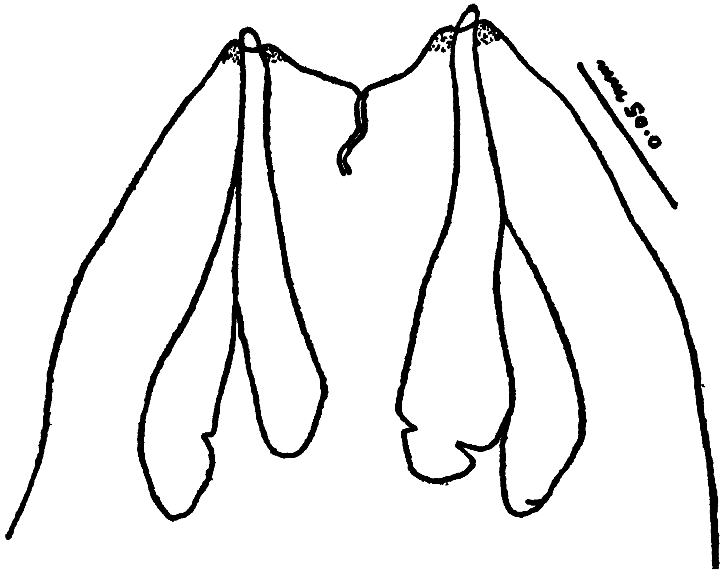

Fig. 5
Diplotriaena nagpurensis
Dorsal view of the anterior end of the male.

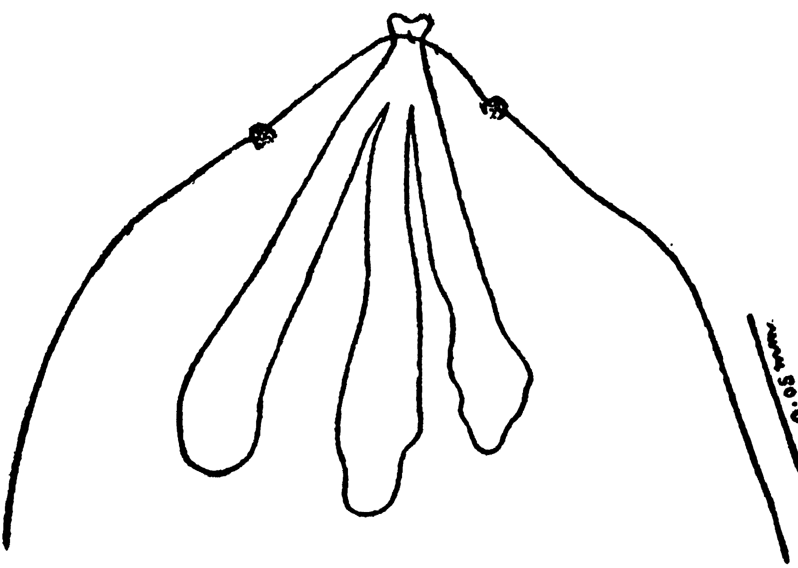

Fig. 6
Diplotriaena nagpurensis
Lateral view of the anterior end of the male.

D. pungens the trident measures 0·25 mm.–0·27 mm.; it is only 0·165 mm. in the present species. The tridents in *D. nagpurensis* protrude beyond the anterior end as in *D. pungens* but the lip-like elevations which are present in the latter species are not present in the former. Moreover in *D. nagpurensis* the anterior end of the trident is distinctly truncate and forms a slight concavity when viewed laterally. The oesophagus and both the spicules are distinctly smaller in *D. pungens* than these structures found in *D. nagpurensis*. According to Schneider's observations *D. pungens* possesses seven pairs of caudal papillae in the male. Boulenger (1928) could observe only three postanal pairs in the single specimen at his disposal. In *D. nagpurensis* no caudal papillae are present in the male. This would show that *D. nagpurensis* is quite distinct from *D. pungens*.

D urocissae is comparatively a much smaller worm than *D. nagpurensis*. Though in *D. urocissae* the tridents project beyond the cuticle of the anterior end just as they do in *D. nagpurensis*, their anterior ends are sharp and not truncated as in the latter species. Again, there are two pairs of caudal papillae in the male of *D. urocissae*, while there are none in *D. nagpurensis*. Thus it would be seen that *D. nagpurensis* is quite distinct from *D. urocissae*.

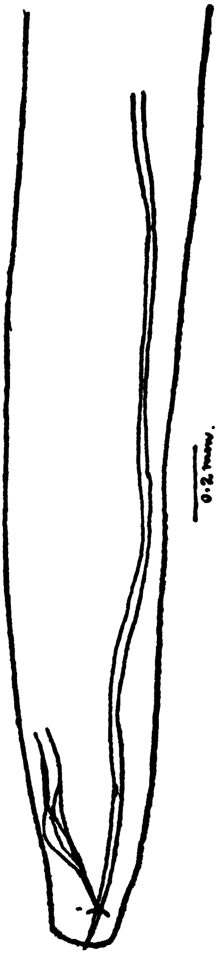

Fig. 7
Diplotriaena nagpurensis
Caudal end of the male.
Ventral view.

Host—Myna (*Acridotheres tristis tristis*).

Habitat—Body cavity.

Locality—Nagpur (C. P.).

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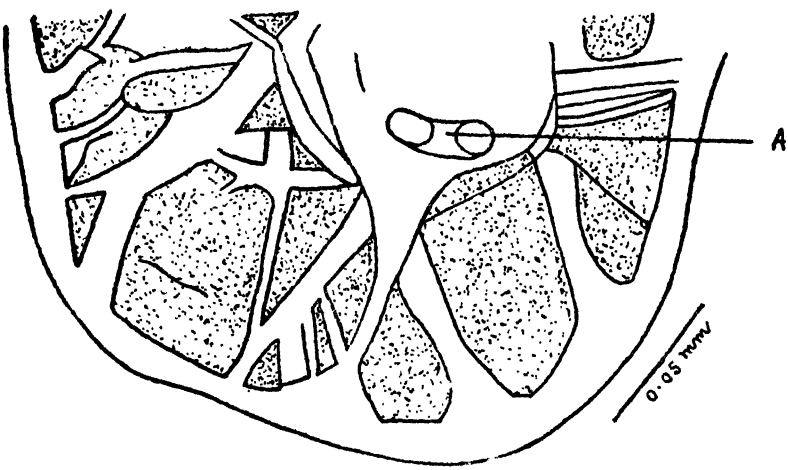

Fig. 8
Diplotriaena nagpurensis
Tail of the male under higher magnification to show the musculature.
A—Anal aperture.

A REPORT ON THE STUDY OF " BLOOD PRESSURE" OF INDIANS IN BOMBAY

By

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During the past decade or two, the importance of sphygmomanometeric measurements has increased to such an extent that to-day it is considered a necessity to estimate the blood pressure as a matter of routine either in the consulting room or at the bedside. The technique of measuring the blood pressure has been so simplified by the introduction of the auscultatory method that it comes within the scope of every general practitioner to make a fairly accurate estimate of the same. Its value from the points of view of diagnosis and prognosis cannot be ignored.

To understand the proper significance of an individual's blood pressure reading in any pathological condition, it is essential to have a definite idea of the normal range of variations under physiological conditions. A good deal of work has been done in other countries on normal blood-pressure and the extent and nature of departure from the normal in various pathological conditions. But unfortunately no such ground work has been done as regards the people of this country. The only reference that we have been able to find is in the work of McCay on the systolic blood pressure of Hindus of Calcutta. The work of Cadbury among Chinese students at Canton and of other observers among people in semi-tropical places suggests that the blood pressure of Indians ought to be lower than that of people residing in more temperate climates. It is with a view to have an idea of the blood pressure and its variations in physiological states under the peculiar environments in India (Bombay) that this investigation was taken in hand. An attempt has been made to give a statistical treatment to the data collected from the materials at our disposal with a view to getting a better understanding of the causes responsible for its variations. The blood pressure in cases of Pneumonia was also studied from the materials available in the medical wards of the K. E.

M. Hospital; but this will form the subject of another paper. The work was started at the end of September 1930 and was brought to a close in October 1932. During this period the blood pressure of 1,302 persons was measured. Of these 1,012 were Hindus, 108 were Christians, 113 Parsis, 64 Mohamedans and 5 Jews.

Materials and the method.

The basal blood pressure, *i. e.* the blood pressure under basal conditions of metabolism was investigated among those of the students, resident medical officers, nurses and the clerical staff, residing on the premises of the group of hospitals in Parel. The blood pressure during working hours was studied in addition, amongst school children attending Dadar schools and amongst clerks of the Municipal Head Office and among students of the Ismail College, Andheri.

Throughout our investigations we have adopted the horizontal position (recumbent posture) without a pillow or with a low pillow under the head. The subjects were allowed to lie down for about five minutes on the couch during which period a record of the name, sex, relevant personal history, family history and habits (especially as regards food, alcohol and tobacco) was made in order to allow time for the subjects to get over the nervousness and become familiar to the examiner before the readings were taken.

A mercury manometer graduated in Mms of Hg. with a standard 12 c. m. arm cuff was used. The pulse rate was counted for half minutes until two countings tallied. Three blood-pressure readings were taken and the average of the last two readings was recorded. The systolic blood pressure was read at the appearance of first clear sound and the diastolic at the point of transition between the 3rd phase of sharp clear sounds and the 4th phase of muffling of the sounds. A record of the height and weight was obtained and the urine of the subjects was examined for albumin and sugar.

We have omitted from consideration those cases which presented any cardiovacular abnormality (except sinus arrhythmia) and those cases which showed presence of albumin or sugar in the urine. In our series, 12·25% of school children between 6 and 20 years of age showed respiratory or sinus arrhythmia. The urine of 4 out of 522 children showed a faint reduction with Fehling's solution but the problem was not investigated further. Three children gave positive tests for albumin by the heat and sulpho-salycilic acid tests.

RESULTS.

Blood Pressure of Hindus.

The average systolic pressure of Hindu boys between 5 and 9 years of age was found to be 84·2 mms. For boys between 10 and 19 years of age, it was found to be 93·4 mms. For adults of 20 to 29

years, 30 to 39 years and 40 to 49 years it was found to be 114·5, 120·8 and 116·5 mms. respectively. The systolic blood pressure of all the adult age groups mentioned above, does not show a fluctuation greater than can be accounted for by chance variation alone, and here we agree with Wing Commander Treadgold that "age between 18 and 40 and proportionate height and weight have little effect on blood pressure". The majority of this group (Hindus) were vegetarians and teetotallers. Those of them who styled themselves non-vegetarians had in addition to the vegetarian diet a few eggs and few ounces of meat or fish once or twice a week. All the medical students who took a fair amount of exercise fall in the age group 20 and 29 years whilst in the higher age group are included clerks and others following a sedentary occupation. The results are arranged in Table I. Similar figures from English and American sources are given in Table IIIa. The figures found by us for the various age groups are considerably below those given by those authors. Compared with Americans our subjects showed a difference of 14·9 mms. in the systolic pressure. McCay at Calcutta found the systolic blood pressure of Hindus to vary between 83 and 110 mms., the average being a little over 100 mms. In another series of observations he found the averages to be more or less the same. Our figures as compared to McCay's are slightly higher both as regards the average as well as the range of variation. Cadbury working with Cantonese students found the averages which are given below :—

Cadbury			*Our work*		
14 years.	Systolic.	83 mms.	10 to 19 years.	Systolic	93·4 mms.
	Diastolic.	51 „		Diastolic.	56·1 „
	Pulse.	31 „		Pulse.	33·48 „
15 to 20 years.	Systolic.	101 mms.			
	Diastolic.	62 „			
	Pulse.	39 „			
21 to 30 years.	Systolic.	101 mms.	21 to 30 years.	Systolic.	114·52 mms.
	Diastolic.	68 „		Diastolic.	73·23 „
	Pulse.	36 „		Pulse.	44·32 „

It will be noticed that our figures are higher than those of Cadbury. He found that 60% of his subjects had blood pressure ranging between 90 and 110 mms., whilst 57·4% of our subjects had a systolic blood pressure ranging between 90 and 119 mms. 81·8% of the Hindu nurses examined had a systolic blood pressure ranging between 90 and 119 mms. It will be noticed that there were several cases that showed a systolic pressure of over 130 mm. They form 0·26% in the age group 10 to 19 years, 10·9% in the age group 20 to 29, 22·2% in the age group 30 to 39 years and 18·7% in the age group 40 to 49 years. The subjects who had blood pressures below average were

found to have no symptoms and were as fit as others, showing that "hypotension, even when systolic pressure is below 100 mms., can be present in good health."

The results of the *diastolic pressure* readings are tabulated in Table II. Here again we find that our figures are lower by about 10 mms. than the figures given for Americans. In McCay's work we find no reference to diastolic pressure. Our figures are a trifle higher than the figures of Cadbury for Chinese students. About 76% of our subjects had diastolic pressures between 60 and 79 mms. Nearly 20% had diastolic pressure below average. The average figures show little variation in the age groups above 20 years.

Pulse pressure readings are tabulated in Table III. The average pulse pressure for adults was found to be 44 mms. In children it is slightly lower than in adults and slowly increases with age. It rises in proportion to the height of systolic blood pressure as will be noticed below.

Body Weight and Blood Pressure.

The blood pressure in the age group 5 to 19 years has been tabulated in Tables IV,V and VI. The systolic blood pressure shows a steady increase with increase in body weight. The same is true for the diastolic pressure also though it does not show the same amount of increase as the systolic. Consequently we find that the pulse pressure rises; the difference being due more to the rising systolic pressure than to the diastolic, a fact that has been noticed by other observers before. Table VII shows a comparison between the results of Michael and of Cadury and of ourselves. Our figures though higher than Cadbury's are considerably lower than the figures given by American authors.

The relation between body height and blood pressure of the age group 9 to 19 years is shown in Table VIII, and Table VIII (*a*) shows similar figures for American subjects. The systolic blood pressure rises gradually as the height increases. Though the relative increase is the same in Indians and in Americans, the absolute figures for the latter are higher by about 10 mms. The diastolic pressure too shows a slight increase with increased height.

Blood Pressure of other communities.

The systolic and diastolic pressures of Hindu children at Dadar schools were found to be lower than those of the Christian children of the same age and locality. The difference was about 4·7 mms. for systolic blood pressure and 10·41 mm. for the diastolic pressure. The Christian boys were comparatively of better physique than the Hindu boys of the same locality. The students of a Parsi school in the Fort were found to have systolic blood pressure about 7 mms. higher than that of the Christian boys. In the medical students of the Seth G. S.

Medical College, the blood pressure of the students of the various communities was approximately the same. The blood pressure of the Mohamedan students of the Ismail College, Andheri, is shown in Table XI, compared with that of the Hindu students of the Medical College. The figures for the systolic pressure are equal to the nearest integer, whilst the diastolic figures in Mohamedans are higher by 3·8 mms. than in Hindus. The conditions of life of both sets of students are more or less the same except perhaps that the medicoes have to do a greater amount of work than the students of the other college. The average systolic pressure for both the groups is about 113·3 mms. The problem demands more investigation before final conclusions can be drawn therefrom.

Diet and Blood Pressure.

The blood pressure of adults of the age group 30 to 50 years has been classified from the point of view of diet in Table XII. The subjects classified as vegetarians in the Table were total abstainers from all animal food except milk. The non-vegetarian diet consisted of a few eggs and a few ounces of meat or fish daily, besides the usual diet consisting mainly of rice, wheat and vegetables. The systolic blood pressure of vegetarians was found to be 112·0 mms. and that of non-vegetarians was found to be 120·0 mms.—a difference of 8 mms. The average diastolic was found to be 78·4 and 76·2 mms. for the non-vegetarians and the vegetarians respectively—difference of 2·2 mms. All these subjects were clerks employed in the various departments of the Bombay Municipal Head Office having the same conditions of life as regards work, exercise, etc.

Occupation and Blood Pressure.

Table XIII shows the blood pressure of clerks and labour staff of different age groups compared. The labour staff of the hospital consisted of ward boys and gardeners. Most of the subjects of the labour staff had habits of drinking toddy or country liquor and of chewing tobacco, while the number of people who had such habits among the clerical staff was practically nil. The systolic blood pressure of clerks of age between 20 and 29 years was found to be higher by about 4 mms. while that of the clerks of age between 30 and 39 years of age was found to be 7·3 mms. higher than that of the labour staff of the same age. The members of the labour staff had to do a greater amount of manual labour than the clerks. Perhaps the higher figures for the clerks can be accounted for by the sedentary habits combined with inadequate opportunities for physical exercise and worries incidental to their work and to their status in life.

Basal Blood Pressure.

This group consisted of male medical students and female nurses

of the King Edward VII Memorial Hospital. The students were between 20 and 28 years of age while nurses were between 18 and 28 years. The blood pressure was taken between 5-30 a.m. and 6-30 a.m. while the subjects were still in bed. In comparison the blood pressure was again taken at 4 p.m. after they had been working since 8 a.m. The average basal systolic pressure of male students was 103·53 mms. and was 7 mms. lower than that taken during working hours. The working hour diastolic pressure showed a rise of 2·5 mms. from basal diastolic pressure. In the nurses the average basal systolic pressure was found to be 95·6 mms.—lower by about 9·2 mms. than the working hour systolic pressure. The working hour diastolic pressure showed an increase of 5·5 mms. from the basal diastolic pressure. The difference between the working hour blood pressure and the basal blood pressure is greater in the females than in the males. The basal blood pressure of Hindu nurses was found to be higher than that of Christian nurses, which might be due to the greater emotional tone noticed in the former.

Arteriosclerosis.

Another interesting fact brought out in this investigation was the frequency of arteriosclerosis in children as judged by the thickening and palpability of the walls of the radial and brachial arteries. The relative frequency in different communities is shown in Table XV. The average blood pressure of the cases of arteriosclerosis we came across during the course of our investigations is shown in Table XV. There seems to be no definite relation between arteriosclerosis and high blood pressure in these cases. But here again the number of subjects is not sufficient to warrant any conclusions.

Pulse rate.

The average pulse rate for Hindu school children at Dadar between 5 and 9 years of age was found to be 86·5 per minute. Between 10 and 19 years it was found to be 82·5 per minute. For adults it was found to be on an average 75 per minute. The results are tabulated in Table XVI.

The basal pulse rate of students (males) between 20 and 28 years was found to be 63·7 per minute and the working hour pulse rate taken at 4 p.m. was 73·19. Among the nurses between 18 and 28 years it was 70·9 and that taken during working hours was found to be 75·45. The pulse rate of females under basal as well as under working hour conditions was higher than in males.

Summary.

1. The systolic blood pressure of Hindus in Bombay is lower by about 10 to 15 mms. than that of Americans or Englishmen. The diastolic is lower by about 5 mms.

2. The relative proportion between body weight, body height and blood pressure is approximately the same in Indians, as in Americans. "Age has little influence on blood pressure among adults of proportionate height and weight." (Ref. 11).

3. The average basal systolic blood pressure is lower by about 7·14 mms. than the systolic blood pressure taken under working conditions in males and 9·2 mms. in females. The diastolic blood pressure shows smaller variation.

4. The blood pressure of Christian and Parsi children is higher than that of Hindu children but the problem requires further investigation before definite conclusions can be drawn.

5. The systolic blood pressure of clerks and intellectuals is higher than that of manual workers.

6. The blood pressure of people who live on a non-vegetarian diet tends to be higher (by about 8 mms.) than those living upon a vegetarian diet.

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TABLE I.

Systolic pressure in Hindus (Males).

Blood pressure in Mms. of Mercury.	5 to 9 yrs.	10 to 19 years.	20 to 29 years.	30 to 39 years.	40 to 49 years.
60–69 Mms.	3	...	...	...	...
70–79 "	29	31	...	...	...
80–89 "	56	115	...	...	...
90–99 "	22	155	1	2	1
100–109 "	5	56	16	3	5
110–119 "	...	23	25	6	3
120–129 "	...	10	7	10	4
130–139 "	...	1	6	5	3
140–149 "	...	...	...	...	...
150–159 "	...	...	...	1	...
Total...	115	391	55	27	16
Mean.	84·2	93·4	114·52	120·79	116·5
Probable error mean. ...	±0·5025	±0·3411	±0·6717	±1·658	±1·951
Standard deviation.	7·991	10·69	9·309	12·78	11·26
Probable error of standard deviation. ...	±0·3554	±0·2412	±0·5980	±1·172	± 1·374
Co-efficient of variation. ...	9·491	10·72	8·130	15·29	9·899
Probable error of co-efficient of variation. ...	±0·4249	±0·2614	±0·8577	±1·435	±1·472
Percentage above 130 Mms. ...	...	0·26	10·9	22·2	18·75

TABLE II.

Diastolic blood pressure of Hindus (Males).

Pressure in Mms. of Hg.	5–9 years	10–19 years.	20–29 years.	30–39 years.	40–49 years.
30–39 Mms.	10	8	...	...	...
40–49 "	35	24	...	...	...
50–59 "	40	131	...	...	...
60–69 "	29	164	15	5	3
70–79 "	1	59	34	11	6
80–89 "	...	5	4	6	7
90–99 "	...	...	2	5	...
100–109 "	...	...	...	...	...
Total...	115	391	55	27	16
Mean	52·42	56·10	73·226	78·50	77·00
Probable error of Mean. ...	0·5652	0·6176	0·5630	1·223	3·681
Standard deviation.	9·003	18·100	6·255	9·421	21·88
Probable error of standard deviation. ...	0·4004	0·4367	0·4018	0·8648	2·609
Co-efficient of variation. ...	17·18	32·42	8·545	12·00	28·41
Probable error of co-efficient of variation. ...	0·7863	0·4512	0·5530	1·118	2·812

TABLE III.

Pulse pressure of Hindus (males).

Pressure in Mms. of Hg.	5–9 years.	10–19 years.	20–29 years.	30–39 years.	40–49 years.
10–19 Mms.	3	7	...	...	...
20–29 „	40	138	1	...	...
30–39 „	47	157	21	9	6
40–49 „	22	68	22	13	8
50–59 „	3	19	10	3	1
60–69 „	...	2	1	2	1
Total ...	115	391	55	27	16
Mean.	32·94	33·48	44·32	43·7	44·62
Probable error of Mean. ...	0·5034	0·2945	0·4665	1·048	1·271
Standard deviation.	8·004	8·636	5·018	8·074	7·532
Probable error of standard deviation. ...	0·3559	0·2083	0·3298	0·7411	0·8982
Co-efficient of variation. ...	24·3	26·1	11·58	18·49	16·91
Probable error of co-efficient of variation. ...	1·596	0·6866	0·7543	1·752	2·067

TABLE III a.

Blood pressure of Europeans and Americans.
Average blood pressure (in Mms. of Hg.) Comparison of the results of three investigators.

	Males.		Females.	
	Systolic.	Diastolic.	Systolic.	Diastolic.
Age 15–29 years.				
Alvarez.	129·4	...	126·3	83·7
Dunham.	122·0	76·0	...	...
Symmonds.	123·4	79·8	120·6	78·4
Age 30–39 years.				
Alvarez.	130·4	...	129·8	86·1
Dunham.	123·0	77·0	...	...
Symmonds.	124·3	82·0	122·4	80·9
Age 40–49 years.				
Alvarez.	133·4	...	141·4	91·4
Dunham.	127·0	81·0	...	...
Symmonds.	127·3	84·3	126·9	84·1
Age 50–59 years.				
Alvarez.	144·1	...	157·3	96·1
Symmonds.	131·2	86·5	132·1	87·3
Age 60 Years and over.				
Dunham.	134·1	83·0	...	...
Symmonds.	131·2	86·6	135·5	89·8
All ages.				
Alvarez.	134·7	...	137·6	89·8
Dunham.	125·0	78·1	...	...
Symmonds.	125·3	82·1	122·8	80·5
Halls Dally.	127·0	84·0	123·0	81·0

TABLE IV.

Comparison of systolic blood pressure and weight.

Age group 5 to 19 years (males).

Pressure in Mms.	lbs. 40–49	lbs. 50–59	lbs. 60–69	lbs. 70–79	lbs. 80–89	lbs. 90–99	lbs. 100–109	lbs. 110–119	lbs. 120–129	lbs. 130–139	All weight.
60–69	...	1	...	...	...	...	...	...	...	...	1
70–79	24	14	1	...	...	...	...	...	...	...	39
80–89	62	55	22	7	2	2	...	...	...	...	150
90–99	37	65	46	26	12	12	6	1	...	...	205
100–109	11	21	17	12	14	21	9	15	2	...	122
110–119	3	5	2	4	15	11	13	16	6	4	79
120–129	...	1	3	1	3	4	4	3	5	2	26
130–139	...	...	...	...	...	...	...	1	5	2	8
140–149	...	...	...	...	...	...	1	...	0	1	2
Total ...	137	162	91	50	46	50	33	36	18	9	632
Mean.	87·1	91·29	95·16	97·7	105·59	105·1	110·26	111·22	111·72	114·5	96·86
Probable error of mean.	0·5079	0·5772	0·7257	0·3173	0·9572	0·5585	0·254	0·8186	1·054	7·193	0·2705
Standard deviation.	8·8	10·89	10·27	8·35	9·625	9·258	10·65	7·264	9·458	10·12	10·07
Probable error of standard deviation.	0·3591	0·4032	0·5133	0·2244	0·6769	0·3941	0·8866	0·5774	1·068	5·087	0·1913
Co-efficient of variation.	10·05	11·93	10·78	8·55	9·13	8·80	9·658	6·553	8·474	8·835	10·4
Probable error of co-efficient of variation.	0·4175	0·4545	0·5455	0·5902	0·6476	0·7537	0·8095	0·5217	0·9752	4·559	0·1995

TABLE V.

Comparison of diastolic pressure and weight. (Age 5 to 19 years.) Males.

Pressure.	lbs. 40-49	lbs. 50-59	lbs. 60-69	lbs. 70-79	lbs. 80-89	lbs. 90-99	lbs. 100-109	lbs. 110-119	lbs. 120-129	lbs. 130-139	All weights.
30-39 Mms.	4	5	...	...	...	...	...	...	...	...	9
40-49 „	26	15	2	...	1	...	...	...	...	...	44
50-59 „	49	57	28	13	3	6	1	1	...	...	158
60-69 „	49	66	44	25	23	23	12	7	6	2	257
70-79 „	9	19	16	10	17	20	18	23	11	6	149
80-89 „	...	...	1	2	2	1	1	5	...	1	13
90-99 „	...	...	...	...	...	...	...	...	1	...	1
100-109 „	...	...	...	...	...	...	1	...	...	...	1
	137	162	91	50	46	50	33	36	18	9	632
Mean.	56·9	59·36	62·96	64·57	66·97	67·7	71·47	69·51	72·2	73·6	63·06
Probable error of Mean.	0·5125	0·4684	0·5037	0·9259	0·6988	0·9229	0·9191	1·451	1·016	2·688	0·2809
Standard deviation.	8·894	8·83	7·125	9·374	7·028	9·078	7·827	12·90	6·395	3·738	10·46
Probable error of standard deviation.	0·3624	0·3562	0·3562	0·8418	0·4942	0·8445	0·6500	1·026	0·7888	1·879	0·1986
Co-efficient of variation.	15·63	14·89	11·32	9·799	10·49	9·904	10·95	18·57	8·857	5·078	16·59
Probable error of co-efficient of variation.	0·6539	0·5702	0·5733	0·8961	0·9391	0·9084	0·9202	1·528	1·071	3·147	0·3311

TABLE VI.

Comparison of pulse pressure and weight of boys (age between 5 and 19 years.)

Pressure.	lbs. 40–49.	lbs. 50–59.	lbs. 60–69.	lbs. 70–79.	lbs. 80–89.	lbs. 90–99.	lbs. 100–109.	lbs. 110–119.	lbs. 120–129.	lbs. 130–139.	All weights.
10–19 Mms.	3	4	...	1	...	...	...	...	...	...	8
20–29 "	56	60	25	15	6	9	5	3	1	1	181
30–39 "	57	71	46	20	19	24	14	16	5	1	273
40–49 "	17	24	17	12	16	13	12	16	10	6	143
50–59 "	4	3	3	1	4	4	2	1	2	1	25
60–69 "	...	...	...	1	1	...	...	...	...	...	2
Total.	137	162	91	50	46	50	33	36	18	9	632
Mean.	32·7	32·16	34·2	34·5	39·06	36·9	37·84	38·67	42·6	42·2	31·37
Probable error of mean.	0·4395	0·3934	0·5047	0·8509	0·6829	0·7502	0·8843	0·6955	1·066	5·337	0·3665
Standard deviation.	7·628	7·418	7·139	8·921	6·868	7·865	7·541	6·186	6·701	7·489	13·65
Probable error of standard deviation.	0·3109	0·2783	0·3569	0·6077	0·4829	0·5306	0·6262	0·4918	0·7539	3·774	0·2592
Co-efficient of variation.	23·3	23·1	20·87	25·86	17·58	21·31	19·93	16·00	15·74	17·83	43·7
Probable error of co-efficient of variation.	1·001	0·9103	1·092	1·860	1·274	1·502	1·720	1·307	1·805	9·143	0·8306

TABLE No. VII.

Table showing the relation of blood pressure to body weight of different authors.

Body weight in lbs.	Systolic pressure.			Diastolic pressure.		Pulse pressure.	
	Michael. American.	Cadbury. Chinese.	Indian	Cadbury. Chinese.	Indian.	Cadbury Chinese.	Indian
20–30	...	60	...	30	...	30	...
30–40	95	81	...	51	...	29	...
40–50	100	83	87·1	51	56·9	32	32·7
50–60	107	87	91·29	55	59·36	32	32·16
60–70	112	94	95·16	60	62·96	34	34·2
70–80	116	96	97·7	59	64·57	37	34·5
80–90	122	100	105·59	60	66·97	40	39·06
90–100	126	101	105·1	63	67·7	32	36·9
100–110	...	104	110·26	64	71·47	40	37·84
110–120	...	106	111·22	65	69·51	41	38·67
120–130	...	106	111·72	66	72·2	41	42·6
130–140	...	...	114·50	...	...	...	42·2

TABLE VIII.

Comparison of body height and blood pressure (Males).

Height.	No. examined.	Systolic pressure.	Diastolic pressure.	Pulse pressure.
		Mms.	Mms.	Mms.
3′–6″ to 4′–0″	98	85·3±0·5384	52·7±0·6657	32·7±0·6132
4′–4″ to 4′–6″	255	88·3±0·4592	60·3±0·6422	32·2±0·4145
4′–6″ to 5′–0″	102	97·9±0·7964	66·1±0·5829	34·6±0·5599
5′–0″ to 5′–6″	135	108·6±0·5899	71·6±0·4335	39·6±0·4096
5′–6″ to 5′–9″	33	112·4±1·024	72·3±0·7930	39·9±0·9494

TABLE VIII A

Comparison of blood pressure and body height of American children (Michaels), with Indian Children examined during the course of the present enquiry.

Height.	Systolic pressure.	
	American Children	Indian Children
3′–6″ to 4′–0″	99 Mms. of Hg.	85·3 Mms.
4′–0″ to 4′–3″	109 „	87·5 „
4′–3″ to 4′–6″	112 „	93·1 „
4′–6″ to 4′–9″	118 „	94·3 „
4′–9″ to 5′–0″	120 „	100·3 „
5 feet and over.	125 „	108·0 „

TABLE IX.

Comparison of basal blood pressure and blood pressure during working hours (Males 52. Ages 20–28).

	Basal blood pressure.	Evening.	Difference.
Systolic pressure	103·53±·4867Mms.	110·64±1·361 Mms.	7·14±1·446 Mms.
Diastolic „	70·0 ±·4588 „	72·5 ±·7723 „	2·5 ±0·8984 „

(Females—35. Ages 19—24).

	Basal blood pressure.	Evening.	Difference.
Systolic.	95·64±1·052 Mms.	104·83±0·4735Mms.	9·21±1·154 Mms.
Diastolic.	65·49±0·9401 „	70·0 ±0·4942Mms.	5·51±1·061 „

The basal blood pressure was taken in the morning after rest during the previous night and before the subjects had got up and stirred out of bed. The evening blood pressure was taken between 4 p. m. and 5 p. m. on the same day and where it was not possible it was measured between 4 p. m. and 5 p. m. the next day.

TABLE No. X.

Blood pressure of Hindus, Christians and Parsis (males).
5 to 19 years.

	Hindus.	Christians.	Parsis.
No. examined.	391	100	100.
	Mms.	Mms.	Mms.
Systolic pressure.	93·4±0·3411	98·1±0·8726	107·9±0·7017
Diastolic "	56·1±0·6176	66·5±0·4955	71·0±0·4545
Pulse "	33·48±0·2945	36·0±0·4343	36·4±0·5811

TABLE No. XI.

Blood pressure of Mahomedan students (of Ismail College, Andheri) and Hindu students (of the Seth G.S.M. College, Bombay).
20–29 (Males).

No. examined.	Mahomedans. 28	Hindus. 47
Systolic pressure.	113·4 Mms. of Mg.	113·0 Mms.
Diastolic "	78·3 " "	74·5 "
Pulse "	35·1 " "	39·5 "

TABLE XII.

Comparison of blood pressure of vegetarians and non-vegetarians (males) Municipal clerical staff (30–50 years).

No. examined.	Vegetarians 46	Non-vegetarians. 35
Average systolic pressure.	112·0±1·32 Mms.	120·0±1·049 Mms.
" diastolic "	78·4±0·3214 "	76·2±0·6116 "
" pulse "	48·8±0·3214 "	46·0±0·9572 "

TABLE XIII.

Comparison of blood pressure of clerical and labour staff.
(Males.)

No. examined.	Age 20 to 29 years.		Age 30 to 39 years.	
	Clerks. 55	Labour staff. 41	Clerks. 27	Labour staff. 29
	Mms.	Mms.	Mms.	Mms.
Systolic pressure.	114·1±0·6717	111·82±1·023	120·79±1·658	113·47±1·477
Diastolic „	73·26±0·5630.	69·77±1·039	78·5 ±1·233	78·78±0·6993
Pulse „	44·32±0·4665	38·16±1·921	43·7 ±1·048	37·95±0·9895

TABLE XIV.

Blood pressure in Arteriosclerosis.

Age.	No. examined.	Average systolic pressure.	Average diastolic.
10 to 14 Yrs.	15	103·0	64·0
15 to 19 „	19	124·0	72·0
20 to 24 „	3	125·0	77·0
25 to 29 „	1	120·0	76·0
30 to 34 „	6	112·0	77·0
35 to 39 „	3	118·0	79·0
40 to 49 „	1	115·0	81·0
50 to 59 „	...	...	...
60 to 69 „	1	130·0	74·0

		Arterioselerosis in children.
Community.	No. examined.	No. of arteriscelerotic subjects.
Hindus	520	28
Christians	100	6
Parsis	100	2

TABLE XV.

Comparison of average blood pressure & pulse rate of Christian and Hindu nurses. (Age between 18 and 51 yrs.) Majority 20–35 yrs.

Caste.	No. examined.	Systolic pressure.	Diastolic pressure.	Pulse rate.
Christian.	74	109·2	79·3	83·1
Hindu.	33	111·78	79·04	87·7

TABLE XVI.

Pulse rate of men (working hours.)

Age.	5 to 9 yrs.	10 to 19 yrs.	20 to 29 yrs.	30 to 39 yrs.	40 to 49 yrs.
No. examined.	115	391	67	28	19
Pulse rate	86·5±0·3711	82·5±0·3319	74·69±0·6159	77±0·9315	76·6±1·309

TABLE XVII.

Frequency distribution of systolic blood pressure of Nurses (between 19 and 29 years).

	Number examined.	Christians, Indian Christian, Anglo-Indians.	Hindus.
90–99 Mms.	5	5	...
100–109 Mms.	31	20	11
110–119 „	24	17	7
120–129 „	8	5	3
130–139 „	3	2	1
140–149 „	1	...	...
	71	49	22

TABLE XVIII.

Ranges of variation of blood pressure in young adults (20–29).

		Women		Men	
		Basal	Working hours	Basal	Working hours
Systolic.	Max.	120	127 Mms.	122 Mms.	134 Mms.
	Minm.	79	87 "	85 "	90 "
Diastolic.	Maxm.	87	86 "	84 "	84 "
	Minm.	53	54 "	58 "	64 "

TABLE XIX.

Blood pressure and weight in men of age between 25–40 years (Municipal clerks)

Weight in lbs.	No. examined	Systolic pressure	Diastolic pressure
95–99 lbs.	4	107·5 Mms.	69·35 Mms.
100–109 "	7	116·7 "	73·85 "
110–119 "	11	112·45 "	74·72 "
120–129 "	13	113·3 "	70·4 "
130–139 "	10	120·1 "	76·3 "
140–149 "	8	121·0 "	80·8 "
150–159 "	7	123·7 "	82·57 "

TABLE XX.

Blood pressure and height in men of age between 25–45 years (Municipal clerks).

Height in inches.	Number examined.	Systolic pressure.	Diastolic pressure.
55–59	1	105 Mms. of Hg.	74 Mms.
60–62	9	118·7 "	74 "
63–65	24	114·7 "	75·3 "
66–68	23	114·3 "	70·43 "
69–71	5	124 "	83 "

Reviews

Practical Anatomy by Six Teachers, edited by E. P. STIBBE, F. R. C. S. (Edward Arnold & Co.) London, 1932, 30*s.* net.

This book is a useful addition to the current text-books on Practical Anatomy, and is designed specially to meet the requirements of students working for M. B. B. S. examinations in this subject. As stated in the Preface, it is intended to replace the Practical Anatomy of Professors Parsons and Wright, who have generously permitted every use to be made of their original text and illustrations. The six teachers, who have contributed different sections, are Professor W. Wright of the London Hospital Medical School (The Abdomen and Pelvis), Professor T. Yeates of the Middlesex Hospital Medical School (The Thorax), Professor J. S. B. Stopford of the University of Manchester (The Central Nervous System), Professor S. E. Whitnall of the McGill University, Montreal (The Orbit, Eye, and Ear), Professor Mary F. Lucas Keene of the London School of Medicine for Women (the Head and Neck), and Mr. E. P. Stibbe of the London Hospital Medical School (The Limbs). The hints regarding the dissection are concise and practical. In studying each part, the instructions are to study the Skeleton first, then the surface markings and finally dissections. This is how it should be. The Skin incisions, and subsequent steps in the dissection are clearly put, and described in their logical sequence, and well illustrated by numerous diagrams (an important feature of the book). It must prove a difficult task for any author to judge as to how much theoretical descriptions of parts should be included in a practical handbook such as this. This difficulty is successfully overcome, for the book is the outcome of mature teaching experience of a number of distinguished anatomists, and the students will find it a real aid in the Dissection-Room.

S. L. BHATIA

Text Book of Pathology. By ROBERT MUIR, F. R. S., Third Edition. (Edward Arnold & Co.) London, 1933, 35*s.* net.

The third edition of the Text Book of Pathology by Professor Robert Muir has been published four years after its predecessor. It was

first published in 1924 and reprinted in 1924, 1926 and 1927; the second edition came out in 1929, and reprints again in 1930 and 1932. This speaks volumes regarding its immense popularity as a guide to the students of Pathology. In the new edition the general plan remains the same, but numerous additions have been made, bringing the subject matter up-to-date. This book has a scientific and practical outlook and caters specially for the requirements of the student of medicine. Stress has been laid throughout on the fact that disease processes are disturbances of function and structure. It deals specially with the anatomical (gross and microscopic) aspect of Pathological processes, although the biochemical aspect is not ignored, but the student must supplement this by reference to other books. The same applies to the Pathology of Tropical Disease. The book contains sound teaching and maintains a good balance, and the student will turn to it with delight to acquire the fundamentals of the science of Pathology.

S. L. BHATIA

An Outline of Immunity. By W. W. C. TOPLEY, (Arnold & Co.,) London, 1933.

We undertook the review of this book with the same apprehension that the author expresses about his writing a new text-book on Immunology. A text-book it looks, indeed, in title and size; but even a superficial inspection of the contents suggests it to be something better. To attempt to write at this stage of that science is daring enough; and it was for this reason that the volume attracted our attention. On the other hand, we sometimes have wasted so much time, when we have been "caught" by pretentious monographs which are merely chapters of text-books, that a feeling, at the commencement, of distrust towards a book openly called an 'Outline' was explicable. However, the reading of the first few pages gave us at once that pleasant feeling of being in the company of a master. The book is very cleverly written. A man just initiated in the knowledge of immunity may think that it contains nothing new. But the fact is that much more than the outlined phenomena is given by the scientific arrangement of the matter; and both in the selection and elimination of the material, in the correlation of the facts and in the very original and illuminating remarks, the personality of the author, overshadowiug solutions, is manifest enough.

Right at the outset, for instance, he says (p. 3): "Another important change that the immunologist makes in the clinical and epidemiological picture is in regard to the character and extent of the

association between any given parasite and the host species that it infects. He finds that the real range of interaction includes states of equilibrium in which the host shows no overt signs of disease. Whether we call all these conditions latent infections, or refer to many of the hosts as healthy carriers, matters little." As pertinent to similar ideas developed in that chapter, I may mention the tendency to generalize parallelisms and relationships, where perhaps only local phenomena with peculiar conditions are involved. *Webster* and *Clow* (J. Exp. Med. *58*, 465, 1933) have shown that in the case of the intraperitoneal virulence of the pneumococcus in mice, a high peritoneal pathogenicity may be, and often is, accompanied by an almost total lack of nasal infectivity. There may be parallelism between nasal virulence and the tendency of the pneumococcus to set up carrier conditions, but usually there is lack of parallelism with virulence as determined by the intraperitoneal method, used as the test of infectivity.

Even in the descriptive portions, the author manages to insert a stimulating remark, as when speaking of susceptibility to diphtheria, he asks (p. 280): "Is a point reached in natural immunization at which a person resists carrier infection in the clinical sense? Can we grade our Schick-immunes as we grade our Schick susceptibles, putting at the lower end of the scale those who have just attained to the Schick level of immunity and at the upper end of the scale those who are so resistant that virulent diphtheria bacilli are unable to gain lodgement in their throats?"

Sometimes we find the author, we would not say cautious to the extreme, because great caution is necessary in the treatment of this subject, but less favourably disposed to accept results which have as good a claim for acceptance as many others which have been allowed to pass without a remark. He says (p. 146): "Whether the presence of specific sensitizing antibodies affords an effective resistance against the corresponding bacterium we do not know. We should clearly expect that an individual possessing an antibody acting on the surface antigen of a particular bacterial parasite would be more resistant to this organism than another individual from whose blood this antibody was absent." We think that the evidence afforded by the work of *Solis-Cohen*, *Robertson* and *Sia*, *Bull* and *McKee* specially with the counterproof of the absorption test, cannot on the whole be called "scanty."

Proceeding further when the author makes a brief mention of the transmissible lytic agents, we slightly disagree with his method of tackling the subject. Too much emphasis is given to the actual tests of the therapeutic action *in vivo*, when he concludes that the prospects of an inquiry in that direction seem hardly hopeful. The subject of

the Bacteriophage has suffered from the very beginning, from a sort of recklessness, speculation and impatience for results, which were the peculiar characteristics of its worthy champion D'HERELLE. The prospects of the enquiry, I am persuaded, would be more hopeful if attention was paid to the pure knowledge of its nature. Then—and the colloidal theories mentioned by the author (p. 376) will support my contention—we could gain a better control over its behaviour.

The author can hardly be blamed if the chapter on a subject in a formative stage and with such a cumbrous literature and so much experimental evidence as anaphylaxis, hyper-sensitiveness and allergy gives the impression of a less digested treatment. It is, all the same, a clear source of information.

Used as we are, while reading the book, to the apt comments and the appropriate analysis of many real problems, we are sometimes somewhat disappointed in not finding the author clearly expressing himself on certain matters which we, personally, would have liked to find more fully discussed. For example, the negative phase in the response to antigen injection (pp. 171-177).

It may appear that, through fear or through anxiety to be fair, in several cases, no attempt at co-ordination has been made. And yet the fact often observed in our sciences is that without abandoning our theories, we can still defend our particular tenets by carefully combining the established facts with probable occurrences. Leaving out EHRLICH, the past master not only in illuminating the way to many difficult problems, but also in cleverly and almost humorously conjuring up a host of convenient fluid or solid entities with determined function to perform, we find ourselves in our more scared age, resorting also to clever dodgings and laborious straining of our scientific conquests in order to explain several phenomena which come to mar our short-lived enthusiasm for a newly formed theory. Talking of only a minor point, one instance among many which may be cited is the manner in which we explain away the age fluctuation observed in skin-sensibility towards diphtheria toxin.

In the present condition and outlook of this science, which has to deal with subtle and complex phenomena of what we may call overactivated physiology and impalpable biochemistry, it is not unscientific to offer facts arranged in the light of a theory, provided that the objections which arise from further investigation are not distorted to suit any convenient solution. An independent thinker, Mr. Topley to my judgment, is fair in his treatment and sharp in his analysis of all but perhaps some very minor points.

The author is very modest in his claim that the book is a mere Outline intended mainly for medical students. It is more than that: and even specialists, besides the real pleasure which they will experience in reading the book, will find much food for thought.

G. PALACIOS

Human Embryology and Morphology. By SIR ARTHUR KEITH. M.D., F.R.S. Fifth edition. (Edward Arnold & Co.) London. 1933, 32*s.* 6*d.*

The latest edition of Sir Arthur Keith's Human Embryology and Morphology has an individuality all its own. The author who is our one of the foremost authorities on evolution has discussed the embryology and comparative anatomy as revealers of the mechanism of Evolution.

Every stage has been traced in the embryo which marks a new adaptive phase to the varying environment that confronts it and as far as possible the corresponding parallel from phylogeny is simultaneously depicted. This method of studying the ontogeny and phylogeny has enormous advantages in the advancement of further research into many obscure problems in physiology and pathology and to that extent this book serves as a valuable guide to workers in these branches of medical science. The Experimental Embryology with the aid of the advancing methods of Tissue Culture technique is another hopeful avenue through which the inter-relation between the various organs of the embryo can be studied as regards their position, growth and functions. The Chemical Embryology and, particularly, the work of Prof. C. M. Child on metabolic gradients which have not been given enough space in this book are the methods which may ultimately yield results not to be despised by the student of evolution.

Finally, the mechanism of the chromosomes and of the genes that are responsible for the transmission of various traits of the parents into their offspring require a good deal of attention than that received at the hands of the author, if the medical student for whom the present book is intended, is to realise the prospects offered by this branch of science in clearing up many problems of normal and abnormal heredity. The marvellous work of T. H. Morgan on the genes of the Drosophila must serve as a stimulus for similar work on higher animals on account of the tissue culture methods.

As one goes through the work one gets the impression that the evidence afforded by comparative anatomy is rather unequally distributed among the various systems. The circulatory, digestive and visual

systems especially do not get their adequate share. On the other hand, the skeletal and the locomotor systems, the face, the pharynx and the teeth have been very fully and excellently dealt with. On the whole, one can detect more or less a distinct, though unconscious, surgical bias in the stress put on the aspects, normal and abnormal, of embryology. The author seems to be too much apprehensive about the bulk of the book getting out of control; but one does not agree on this point with the author, for in the incomplete state of our knowledge in this branch, its treatment from different points of view, which is the speciality of this book, cannot be too sufficiently dealt with.

The value of this book is enhanced by useful notes appended at the end of every chapter and the liberal use made of illustrations which enable the student to grasp the phases of development more easily and accurately than from mere descriptions.

One specially realises the usefulness of this book for the medical colleges in India, particularly in this presidency, where comparative anatomy or zoology is not studied or taught in the department of anatomy. The book will prove an asset to the students who for want of actual firsthand knowledge are confused when confronted with the study of embryology.

D. B. S.

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TWO UNIQUE PERSIAN MANUSCRIPTS IN THE UNIVERSITY LIBRARY

The Government Collection of Persian, Arabic, and Urdu Manuscripts, deposited in the Bombay University Library, contains some very valuable Persian manuscripts, of which two in particular are proposed to be considered here. These two have a special interest from certain points of view.

One of them is entitled "*Kulliyyāt-e-Ṣā'ib.*" This *Kulliyyāt* contains the poetical works of Mirzā Ṣā'ib (d. 1088/1677-78), who is considered by Mawlānā Shiblī as the "last great Persian poet, superior in originality to Qāānī." (Browne's *Literary History of Persia,* Vol. IV, p. 265). It is a pretty thick manuscript of 451 folios, each measuring 4.7/8 by 9.1/16 inches. The text is inscribed in the middle of the page as well as on the *ḥāshiya,* and enclosed in fine golden *jadwals.* The value of this manuscript lies chiefly in the fact that it was transcribed three years before the death of the poet. What adds greatly to its importance is the fact that it contains five odes written in the handwriting of the poet himself. Three of these autograph odes are reproduced below.

The other manuscript is entitled *Dīwān-e-Ẓuhūrī.* This *dīwān* contains the *ghazals,* and *rubā'iyyāt* of the famous poet Ẓuhūrī of Bijapur, who died in 1025/1616. It was presented to the Collection on 15-5-1921, by S. Bāqir 'Alī, then Secretary to the Urdu Text-Books Translation Board, Poona, now retired Deputy Educational Inspector. It is about the same size as the "*Kulliyyāt-e-Ṣā'ib*". Its unique value lies in this that the whole of it was revised by the poet and that a few odes and a number of quatrains were inscribed in it by the poet himself.

Both of these *dīwāns* belong to the same period and were transcribed by persons other than their authors. They were copied in different countries, one in Persia and the other in India or to be more exact, in the Deccan. They both contain odes in the handwriting of the poets themselves. These facts point to a deeper significance than a mere coincidence. To me it appears that in all probability there existed in the seventeenth century some custom among Muslim literati, both in Persia and India, in conformity to which the transcribers of *dīwāns*, often friends and admirers of the poets, requested the latter to adorn the copies of their *dīwāns* with autograph *ghazals* as mementoes, very much after the manner of the present-day enthusiastic student, who keeps an autograph-album and requests great authors and distinguished personages to inscribe therein some favourite maxim or rule of conduct over their signatures. The abovementioned *dīwāns* appear to me to offer an illustration of some such custom. Moreover, a manuscript like that of the "*Kulliyyāt-e-Ṣā'ib*" has its interest and importance centred in other points of view also. If it is dated, that is, if it bears the date of transcription, the existence of autograph verses helps greatly in determining the date of the poet's death also. It also shows what style of handwriting was prevalent in a particular period in a particular country. Much light is also thrown on other points such as difference between the orthographical forms of *yā-e-ma'rūf* and *yā-e-majhūl*, the *nūn-e-ghunna* and the *nūn-e-mu'lan*, the *sīn* and *shīn* with the "*dandāna*" or without, the *hamza* or *yā* used as a sign of the *iẓāfat* after words ending in *alif*. Some of these points are illustrated in the accompanying facsimiles of the two poets' odes. But before we turn to the odes let us for a moment see who their authors were.

ṢĀ'IB.—Mirzā Muḥammad-'Alī Ṣā'ib was born, as is generally stated, at Isfahān, about 1012/1603. At an early age he went to Kābul and became a favourite of the Governor Ẓafar-Khān, through whom he was introduced to the Emperor Shāh-Jahān, who conferred on him the title of *Musta'idd Khān* and the Command of one thousand. He stayed in India for some time, went to Kashmīr, returned to his native city, Isfahān, where he was appointed poet-laureate by Shāh 'Abbās II. (1052–1077/ 1642–66). He died, according to good authorities, in 1088/ 1677-78. Other dates of his death range from 1080/1669–70 to 1089/1678; but 1088/1677–78 seems to me the most reliable. Our manuscript is dated 1085/1674–75, and contains five odes written by Ṣā'ib himself. Evidently he was alive, in all probability, in 1085/1674–75, and all earlier dates are, therefore, out of the question. A remarkable trait in the character of Ṣā'ib is that, unlike the majority of Persian poets, he admires and appreciates the so-called *Indian* Persian poets, especially Fayẓī, Naẓīrī, and Ẓuhūrī.

He was a great admirer of "Ḥāfiẓ and a careful student of the works of his predecessors, both ancient and modern, and himself compiled a great anthology of their best verses, of which, according to Shiblī, a manuscript exists at Ḥaydarābād in the Deccan. Shiblī compares Ṣā'ib to Abū Tammām, the compiler of the great anthology of Arabic poetry called the *Ḥamāsa,* inasmuch as his taste is shown even more in his selections than in his creative powers." (Browne, *Lit. Hist. Pers.* vol. IV., pp. 268–70). Notices of his life are given in مجمع الفصحا , ریاض الشعراء , تذکرهٔ نصرابادی , تذکرهٔ سرخوش , شعر العجم , آتشکده , ما ثر الکرام where a MS. of his *dīwān* containing 33 autograph odes is mentioned, and last but not least, the late Professor Browne's *Lit. Hist. Pers.* Vol. IV., pp. 265–76. In the latter fortyfive couplets of Ṣā'ib are quoted (from *Kharābāt*) concerning which the Professor remarks :—"They pleased me when I was a beginner, they still please me, and I hope that some of them at any rate may please my readers". Five of these couplets, with Prof. Browne's translation, are given below, which, besides pleasing the readers, will also illustrate one of the outstanding characteristics of Ṣā'ib's style, namely, his partiality for suitable and striking similes and proverbs.

ریشهٔ نخل کهن سال از جوان افزونترست
بیشتر دلبستگی باشد بدنیا پیر را

"The roots of the aged palm-tree exceed those of the young one; the old have the greater attachment to the world."

هر سری دارد درین بازار سودائی دگر
هر کسی بندد بآئین دگر دستار را

"In this market every one has a different fancy; every one winds his turban in a different fashion."

ده در شود گشاده اگر بسته شد دری
انگشت ترجمان زبان است لال را

"Ten doors are opened if one door be shut; the finger is the interpreter of the dumb man's tongue."

موج از حقیقت گهر بحر غافلست
حادث چگونه درک نماید قدیم را

"The wave is ignorant of the true nature of the sea; how can the Temporal comprehend the Eternal?"

خموشی حجت ناطق بود جویای گوهر را
که از غواص در دریا نفس بیرون نمی آید

"To the seeker after pearls silence is a speaking argument, for no breath comes from the diver in the sea."

Ṣā'ib's *dīwān* has always been very popular both in India and Persia. More selections than one have been made from it by different persons, and differently named, such as *Wājibu'l Ḥifẓ*, *Mir'ātu'l-Jamāl*, *Mir'āt'ul-Khiyāl*, etc. The *dīwān* as well as Selections from it was published at Lucknow. Copies of the *dīwān* or of the *Kulliyyāt* exist in every good collection of Persian manuscripts, such as the Mullā Fīrūz Library, Bombay; the Bhāndārkar Oriental Institute, Poona; the Āṣafiyya State Library, Hyderabad (Deccan); the Muslim University Library, Aligarh; the Buhār Library, Calcutta; the Government Oriental Library, Bānkipore; the Asiatic Society's Library, Calcutta; the British Museum, London; the Bodleian Library, Oxford; and the India Office Library, London. Other European Libraries, especially those at Berlin, Munich, Paris, Leningrad, and Upsala, possess copies of the complete works or the *dīwān* of Ṣā'ib. Our manuscript comprises *qaṣīdas*, a *masnawī*, *ghazals*, *maṭāle' mutaffareqāt*, and *fardiyyāt*. Folios 373 *b* and 374 contain the autograph odes written on the margin, of which the former folio is reproduced below. In the colophon the copyist says that the manuscript was transcribed on the 5th Ẕil'-ḥijja, 1085 A. H. 20th February, 1675 A. C., by Muḥammad Rabī' bin Ḥāji Barkhurdār of Isfahān. The autograph odes are exactly in the same style of handwriting as the verses reproduced by Professor Browne in his *Literary History of Persia*, Vol. IV, plate facing page 266. A comparison of the printed text (given below) with the original manuscript will show that it is not always easy to decipher Ṣā'ib's handwriting.

The autograph odes read as follows :—

I

1 داغ عشق از سینهٔ روشن بدست آمد مرا
دامن خورشید ازین روزن بدست آمد مرا

2 با هزاران چشم از دنیا نشد رزق حریص
این گشایش کز نظر بستن بدست آمد مرا

3 مشرق بینش بآسانی نگشتم همچو شمع
سوختم تا دیدهٔ روشن بدست آمد مرا

4 از جوانی خار خاری در بساطم ماند و بس
بوتهٔ خاری از آن گلشن بدست آمد مرا

5 از عصا در عهد پیري کم نشد گمراهیم
پای دیگر بهر لغزیدن بدست آمد مرا

6 دست تعمیر از تن خاکي چسان کوته کنم
وصل آن جان جهان از تن بدست آمد مرا

7 دانهٔ کز باد دستي صائب افشاندم بخاك
در لباس خوشه و خرمن بدست آمد مرا

II

1 تند خوئی باخلائق مهر را کین کردنست
آفرین را درد هان خلق نفرین کردنست

2 شادیٔ ما غافلان در زیر چرخ سنگدل
خنده کبك مست را در چنگ شاهین کردنست

3 لب بشکر خنده وا کردن درین بستان سرا
خون خود چون گل حلال دست گلچین کردنست

4 آرزو را محو از دلهای سنگین ساختن
بیستون را ساده از تمثال شیرین کردنست

5 مستمع را دل بداغ بیشعوری سوختن
شعر خود نا خوانده بیتا باته تحسین کردنست

6 حاصل خاك مراد کشور هندوستان
نا مرادان وطن را کام شیرین کردنست

7 هست اکسیری اگر صائب درین عبرتسرا
روی سرخ خویشرا از درد زرین کردنست

III

1 نعمت الوان دنیا مایهٔ درد سرست
خون فاسد در بدن آهن ربای نشترست
2 علم رسمی میکند دلهای روشن را سیاه
دیدهٔ آئینه را خواب پریشان جوهرست
3 شد ید بیضا ز دامن گیری شب دست صبح
دست کوتاه تو از غفلت همان زیر سرست
4 صحبت نیکان حجاب زنگ غفلت می شود
ایمنست از سیر گشتن آب تا در گوهرست
5 نیست شاه آنکس که دارد گنج گوهر بیشمار
هرکرا سدرمق هست از جهان اسکندرست
6 روی در خلقست و بر زر پشت صائب سکه را
آنچنان پشتی بچندین وجه از رو بهترست

I

1. I got the brand of Love through (my) illumined Soul: (it was) through this window that I caught hold of the skirt of the Sun.

2. This abundance of wordly subsistence which I received through closing my eyes (to wordly wealth, that is, by practising contentment) did not fall to the lot of the greedy man in spite of his having thousands of eyes (opened to the world.)

3. It was not with ease that I became the dawning-horizon of Vision : I had to burn myself like a candle before I got the illumined eye.

4. Only a thorn (of disquietude) is all that is left (to me) in my carpet from (the garden of) youth : from that garden, I have received (as my share) only a thorn-bush.

5. In old age, in spite of the (guiding) staff, my waywardness has not diminished : (the staff is, as it were) an additional foot given to me (with which) I may stumble along.

6. How can I hold (my) repairing hand from the earthy body? It was through (the medium of) this body that I attained to union with the Universal Soul.

7. O Ṣā'ib, the seeds which I have scattered on the earth so lavishly came (back) to me in the form of (numerous) ears (of corn) and a (rich) harvest.

II

1. (Adopting) a harsh temper towards people is turning (their) Love into Hatred, and transforming Approbation in their mouths into Detestation.

2. The (temporary) exultation of us, who are negligent (of our duties) under the hard-hearted sky (Fate), is like the (short-lived) smile of the infatuated partridge, (when) seized by the Royal Falcon with his talons.

3. Opening (one's) lips in a sweet smile in this garden-house (that is, this world) is like allowing the Gardener (who plucks the roses as they open) to shed one's blood with impunity, like the rose.

4. (Trying) to rid the hearts of the hard-hearted of the desires is (like trying) to efface the (sculptured) figure of Shīrīn from the Bīsutūn.

5. To brand the heart of the listener with (the stigma of) Stupidity, is (like) applauding impatiently one's own poetry before it is (even) read out (to others).

6. Those (poets) whose desires are not fulfilled (that is, are not appreciated) in their own homelands reap an abundant harvest in the field of desires of Hindostan.

The interesting article written by Mr. R. P. Masani, M. A., a well-known admirer of Persian poetry, in this journal (Vol. I., Part III., November, 1932) is a sufficient commentary on this couplet. In this connection Professor Browne observes (*Lit. Hist. Pers.* Vol. IV, p. 165): "India at all events, thanks to the generous patronage of Humāyūn, Akbar, and their successors down to that gloomy zealot, Aurangzīb, and of their great nobles, such as Byram Khān-Khānān and his son 'Abdu'r-Raḥīm, who succeeded to the title after his father's assassination about A. D. 1561, continued during the greater part of the sixteenth and the seventeenth centuries to attract a great number of the most talented Persian poets, who found there an appreciation which was withheld from them in their own country. Badāūnī enumerates about one hundred and seventy, most of whom were of Persian descent, though some of them were born in India. Shiblī gives a list of fifty-one, who came to India from Persia in Akbar's time and were received at Court, and a long list is also given by Sprenger. Shiblī quotes numerous verses showing how widely

where he enjoyed the company of the famous poet Mullā Waḥshī of Bāfaq, author of *Khuld-e-Barīn.* From Yazd he proceeded to Shīrāz, where he stayed seven years as an intimate friend of Darwesh Ḥusayn, who was well-versed in history, poetry, riddles, and calligraphy. In 988/1580 he came to the Deccan, and like Malik of Qum, first settled at Ahmednagar and then at Bijapur. At this latter place he became an intimate friend of the poet-laureate, the above-mentioned Malik of Qum, whose daughter he afterwards married. Both these poets, who often collaborated (like Beaumont and Fletcher) in literary productions, were much admired and munificently rewarded by Ibrāhīm 'Adil-Shāh, II (988-1037/1580-1628). Besides the *dīwān,* Ẓuhūrī wrote the famous *maṡnawī* called *Sāqī-nāma* in imitation of Ṣa'dī's *Būstān,* and dedicated it to Burhān Niẓām-Shāh of Ahmednagar (999-1003/1591-94), who sent him elephant-loads of presents. He was not only a gifted poet, but a brilliant prose-man. Amongst his prose works are the '*Introductions*' known as سه نثر, much admired in India, the مینا بازار, and the پنج رقعه, all lithographed several times in India. His proficiency in calligraphy was a source of income to him. He earned large sums of money by the sale of copies which he made of the voluminous history entitled روضة الصفا. His شکسته handwriting won the admiration of the author of the مآثر الامراء. Our manuscript presents specimens of his '*nasta'līq-cum-naskh*' style. Among his contemporaries may be mentioned the poets Fayẓī and Naẓīrī, with whom he used to enter into poetic contests. He was killed in an affray in the Deccan, together with his fellow-poet and father-in-law, Malik of Qum. The date of his death, according to Āzād and several other authorities, is 1025/1616, though other dates ranging from 1024 to 1027 have also been given. He has always been admired in India and has evoked high praise from great poets like Ghālib of Delhi, and others. It is a matter of surprise that though Ẓuhūrī was a Persian both by birth and education, he does not appear, like the proverbial prophet, to have been appreciated in his own country. An account of his life and works is given in such Persian *Tazkiras* as خزانهٔ عامره, آتشکده, مرآة الخیال, سرو آزاد, etc. His works have been lithographed several times in various parts of India, and some of them have been annotated more than once. Manuscript copies of his *dīwān* or of his complete works also exist in almost every decent collection of Persian manuscripts, in India and Europe. Our copy of his *dīwān* has on its title-page the following remark :—

دیوان افضل الشعراء حضرت مولانا ظهوري عليه الرحمه و المغفره
و جا بجا خط شريف ايشانست و از اول تا بآخر بنظر مبارك فيض اثر
ايشان گذشته

From this it is clear that the whole of this *dīwān* was revised by the poet, who also wrote in it several verses with his own hand. The *ghazals* in our copy are differently arranged from those in other copies. Our copy is more correct and more full than the *dīwān* printed by the Nawalkishore Press, in 1897. This latter does not contain the *quatrains;* while our copy contains a large number of them. Against the ode beginning with :—

پیش خدنگت از دل پیران نشان بماند
وز قامت تو قد جوانان کمان بماند

there is a remark on the margin, which runs as follows :—

این تمام غزل از خط شریف ایشانست

After the first eight *rubā'iyyāt* the following remark has been made on the margin :—

از اول رباعی تا اینجا خط شریف حضرت مولانا ظهوری
مرحوم است

Similar remarks are found in other places also. The ode in Ẓuhūrī's handwriting is reproduced below :—

1 پیش خدنگت از دل پیران نشان بماند
وز قامت تو قد جوانان کمان بماند

2 تنها نه صبر من ز تو پا کرد در رکاب
بنما بمن کسی که بدستش عنان بماند

3 کردیم زود قطع سخنهای دیگران
حرف تو جوهر است بتیغ زبان بماند

4 در رزمگاه غمزهات آسوده خاطرم
از فکر این که زخم دگر در سنان بماند

5 شاید که لاله داشته باشد ز رشك رنگ
داغی که از تو بر جگر ارغوان بماند

6 در باغ دوش حرف دهان تو میگذشت
تعریف غنچه در دهن باغبان بماند

7 کم مایه بود غیر ز سودائیان نشد
یك غم نگشت سودش و در صد زیان بماند

8 امید مغز پروری از خوان وصل بود
در سینهٔ هوس خلش استخوان بماند

9 خیر از کسی مجو که کند دعوی توان
خیری کند ظهوری از و نا توان بماند

1. The targets for your arrow are the hearts of old (experienced) men; the statures of young men are bent down like the bow before your (tall and graceful) stature.

2. It is not my patience alone that has put its foot in the stirrup (and vanished); show me a single person who still holds in his hands the reins (of self-control).

3. We soon put a stop to all talk of others; the talk about you remained (permanently) on the tongue, (like) the (indelible) marks (upon the blade of a sword).

4. (Now that I am) on the battlefield of your amorous glances (I am sure to be killed and so) I am free from the anxiety that there may be another spear-thrust coming.

5. Possibly the tulip has got its tint out of jealousy for the brand put on the heart of Judas by you.

6. Last night when your mouth was being extolled in the garden, the praise of the (beauty) of the (rose) bud remained (unexpressed) in the mouth of the gardener.

7. Poor (and pitiable) was the stranger (rival lover), (as) he did not become one of the mad lovers; he did not gain the advantage of a single pang (of Love), while he suffered a hundred losses.

8. Marrow-nourishment was expected from the table of Union; but the pricking of the bone remained in the chest of desire (that is, the Desire was not entirely fulfilled as expected).

9. Do not expect Charity from one who boasts of possessing Strength. It is only Ẓuhūrī who practises (real) Charity, and that

is the reason why he has become so weak (through his having practised it on such a large scale).

The following peculiarities amongst others, of the handwriting of Ẓuhūrī are noticeable :—

(1) His handwriting (and also that of the copyist of his *dīwān*) is quite different from that of Ṣā'ib. It has a *naskhī* turn, which bears a striking resemblance to that of Jāmī.

(2) Unlike Sā'ib the letters س and ش are uniformly written, with their 'teeth' brought out distinctly. Cf. پیش (l. 1), بدستش (l. 2), سخنها ی (l. 3), and شاید (l. 5).

(3) The letter ن whether غنه or معلن is uniformly dotted. Cf. پیران, نشان, کان, (l. 1), and all the rhyme-words, من (l. 2), دیگران (l. 3) etc.

(4) In accordance with the Persian practice no distinction is made between the letters گ and ک. Cf. خدنک (l. 1), دیکران (l. 3), رزمکاه (l. 4). etc.

(5) In common with the classical poets Ẓuhūrī omits the letter ا of است when it follows a silent letter. Cf. جوهر ست.

The idea of جوهر آئینه in couplet No. 2, Ode No. III, of Ṣā'ib remained obscure for some time. Available dictionaries could not give much help in its elucidation; when a remark made by my friend, Mr. Moḥammad-'Alī, a veteran teacher of the Urdu Training School, Poona, that he remembered to have come across the expression in Ghālib, led me to ransack his *dīwāns* for it. My labour was amply repaid when three couplets in his Urdū *dīwān* and one in his Persian, were found to contain it. A reference to the commentators was made for its explanation. Where others failed, Professor Ṭabāṭabā'ī, of Nizam's College, succeeded. In explaining the couplet (of Ghālib) :—

جلوہ از بسکہ تقاضای نگہ کرتا ھے - جوھرِ آئینہ بھی چاھے ھی مژگان ھونا

he remarks : یہان آئینہ سے آئینۂ فولادی مراد ھے کہ جواھر اوسی مین ھوتے ھین

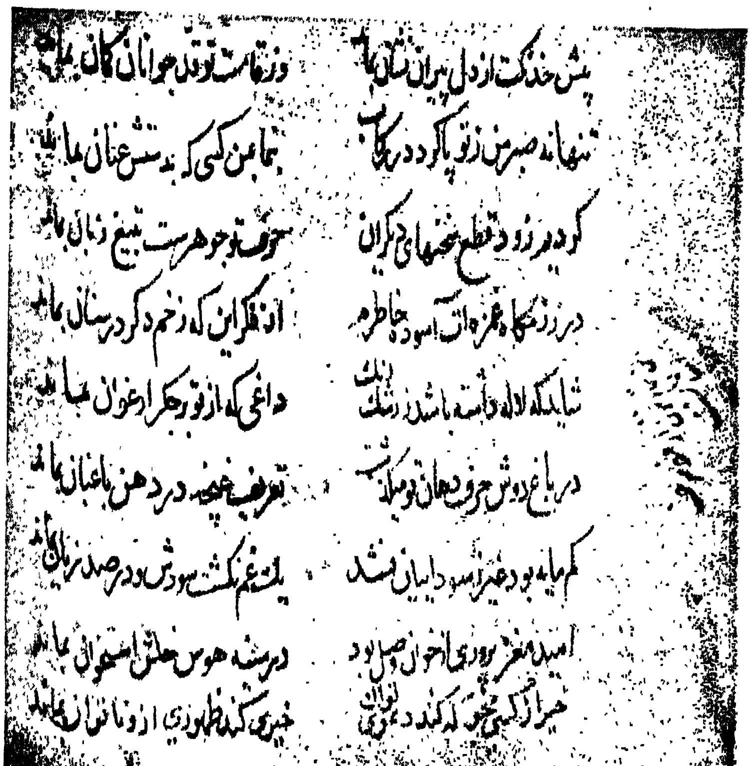
A flood of light was thrown on Ṣā'ib's couplet. He compares

دل روشن with a bright burnished steel-mirror (آئینه), علم رسمی with آئینه (نقوش) جوهر, (what enhances the literary beauty of the language is the fact that both علم and رسم also signify *marking, inscribing, delineating etc.*), and the intermingled and indistinct images seen in خواب پریشان, with the intertwined and distraught marks on the fine steel (of the mirror). I feel much thankful to Mr. Moḥammad-ʻAlī for the suggestion, and Mr. Ṭabāṭabā'i for the explanation.

I also gratefully acknowledge the valuable help which I received from Khan Saheb S. Bāqir-ʻAlī, (retired Deputy Educational Inspector, Poona, and a reputed sound scholar of Persian, Urdu and English languages) in trimming this article, and especially in settling the translation of the difficult couplets of Ṣā'ib and Ẓuhūrī.

SHAIKH ʻABDU'LKĀDIR.

PLATE I.



Facsimile of Ẓuhūrī's handwriting. MS. No. 50. Govt. Collection of Persian, Arabic and Urdu MSS., in the University Library, Bombay.

بسیر اندرون پیش اهل جهان / صد جواب صواب اگر داری

نفس بدان نگاهداری کن / نعمت بی حساب اگر داری

الست در شیر خود مکن چو چراغ / در سرا ماهتاب اگر داری

نیست چون نافه حاجت اظهار / در گره مشک ناب اگر داری

دار پوشیده زیر پیش خود را / در سخاوت حجاب اگر داری

مند چه جا بقیه است گوهر / تشنه سال بیخ آب اگر داری

از صحبت بدی خلق مپسند / ... فتح باب اگر داری

که قلم کرد پای غفلت شکست / صد مجلد کتاب اگر داری

پیر و ... همه جا / ... اگر داری

... ز ... مگذر / آرزوی شباب اگر داری

اگر ... خود ... / گل ... چیده ...

... منبع ... / ... گرد ... شکست

... مغفرت ... داری / اگر ... جهان ... شکست

... گشت ... / اگر دامن ... چیده

ترا ملک سلیمان ... / اگر کلک ... چیده

... گرد ... شکست / غبار ... گرد ... چیده

AN ANCIENT COPY OF THE *DA'Ā'IMU'L-ISLĀM*

I.

In editing the *Kitābu'l-Waṣāyā* from the *Da'ā'imu'l-Islām* of Qāḍī an-Nu'mān, it was pointed out that ancient MSS. were difficult to obtain[1] and that the examination of the four MSS. at my disposal led to the reconstruction of a text which in all probability has not altered for the last three centuries or so. I had also mentioned that the oldest MS. of the second volume that I had come across was dated the middle of the ninth century A.H. (middle of the 15th century A.D.), but that it had been impossible to collate my text with it.[2]

Through the kindness of the Ḥaḍrat Maulānā Ḥājī Ghulām Ḥusayn Ṣāḥib, the High Priest of the Sulaymānī Bohoras in India, however, I have now been able to examine this copy carefully and to note the variants in the *Kitābu'l-Waṣāyā*. Knowing how secretive the Ismā'īlī divines generally are in these matters, and having had several unpleasant experiences in the past, I am sincerely grateful to him for his kindness and courtesy.

The copy was examined in Bombay during the month of March, 1934. It belongs, as does *C*, to the library of the Sulaymānī, Da'wat. The scribe is unknown; his name has unfortunately been carefully deleted. The writing is well-formed Yemenite *naskh*; or at any rate, if it is Indian, written under a strong South Arabian influence. It is a very correct and legible manuscript, and is vocalized to a large extent, although not completely. Size 12 by 7 inches. 23 lines to the page. 146 folios. The paper is handmade, of local manufacture, and is badly worm-eaten. The manuscript has recently been repaired and bound.

On examining the first page of the first folio it is evident that it is the last page of volume I. Volume I is unfortunately lost; the colophon records the name of the scribe and the date of completion in the following terms:

كتب العبد الضعيف الفقير الراجي الى رحمة الله الكريم الوهاب

غفر الله له و (the name here is completely erased)——

1. *Ismaili Law of Wills*, Preface; and 21 sqq.
2. In "Qadi an-Nu'man, the Fatimid Jurist", *JRAS* for 1934, p. 24, I give a slightly erroneous date in referring to this MS., A.H. 852. It ought to be 865/1461.

لوالديه ولقاريه ولناظره بحق محمد و آله اجمعين،

تمت كتاب الجهاد، وقد فرغ من كتاب دعائم الاسلام

في يوم الحادي والعشرين من شهر ذي القعدة وكان يوم الاربعاء

وقت الضحى وكان سنة خمس و ستين و ثمان مائة،

The question of date is interesting. The first of Dhū'l-Qa'da 865 was Saturday, the 8th August 1461. Accordingly the 21st Dhū'l-Qa'da would be 28 August 1461. This, according to Wüstenfeld-Mahler's *Vergleichungs-Tabellen* (2nd Ed., Leipzig, 1926. Page 23) would be a Friday. But the scribe mentions *Wednesday*; and the explanation seems to be that according to the Ismā'īlī calculation, based not on the actual visibility of the New Moon but on its astronomical appearance, the month commenced on the 6th August (not the 8th), and thus Wednesday the 26th August 1461 seems to be the actual date of completion.

Volume II commences on the second page of the first folio in the usual manner. *Kitābu'l-Waṣāyā* begins on folio 91*a* (p. 181). The colophon is as follows:

كتب العبد الضعيف النحيف

الراجى الى رحمة الله الكريم الوهاب

(name obliterated) غفرالله له ولوالديه

ولقاريه و لناظره بحق محمد و آله،

تم كتاب الدعائم فى الحلال

و الحرام و القضايا [والأحكام]

عن اهل [البيت عليهم] الصلواة

و السلام و سلّم تسليماً،

و قد فرغ من كتاب دعائم الاسلام فى يوم الجمعة من ثالث

عشر من ذى الحجة سنة خمس و ستين و ثمان مائة،

The first of Dhū'l-Ḥijja 865 is according to the usual computation, Monday, 7 September 1461. Therefore the 13th of Dhū'l-Ḥijja would be Saturday, 19 September 1461. But the scribe mentions Friday, and it is here also obvious that the discrepancy arises on account of the Ismā'īlī calculation which is always a day or two ahead of the usual reckoning, the new moon being generally visible only on the 2nd or the 3rd day after New Moon. Hence Friday 18 September 1461 seems to be the real date of completion.

We do not know how much time was taken for transcribing Vol. I. But Vol. II seems, if the colophon is to be believed, to have been copied in 22 days. There is nothing inherently impossible in this as the task of copying 146 folios in that time involves the labour

of transcribing 13-14 pages per day—a task which is not uncommon even in these days of lack of zeal and irreligion.

The text as far as I have been able to examine it, and particularly that of *Kitābu'l-Waṣāyā*, is very accurately copied and correctly vocalized. This means that the text of the *Daʿā'im* has not altered materially now for some five centuries, 200 years more than what I formerly ventured to suggest.[1] In the humid climate of India an Ismāʿīlī MS. five centuries old is a great rarity, and although one hears of very ancient MSS., one is usually disappointed at their comparative youth. This MS. is therefore a great find and a treasure in the hands of the Sulaymānī Daʿwat.

A curious coincidence is that the date of transcription is 865 A.H. and Nuʿmān died in 363 A.H.; that is, 5 centuries after the author's death, and a decade less than 5 centuries from to-day. On the whole, the character of the writing, the condition of the paper and other characteristics point to the fact that the date is not spurious, and that in all probability it is a MS. dating from the time of that great historian of the Daʿwat, the illustrious author of *ʿUyūnu'l-Akhbār*, ʿImādu'd-dīn Idrīs b. Ḥasan, 19th Dāʿī of the Yemen.[2] One hears occasionally of copies of the *Daʿā'im* copied by Saiyid-nā Idrīs himself or by his son Ḥasan, but until one has an opportunity of examining them and deciding on their genuineness, it is safe not to be too credulous and to treat the copy described above as one of the best of existing sources for the text of the second volume of the *Daʿā'im*.

II.

I now propose to give some of the interesting variants which I have noted in the text of *Kitābu'l-Waṣāyā*. On the whole the text is remarkably correct and very carefully vocalized. The variants recorded contain either slight corrections to the text (e.g., p. 35, l. 6; p. 61, l. 7), or slight variations which may be worth consideration. The most interesting variant is p. 40, l. 7, where by a very slight change the variant improves the text considerably. The text preserved in this MS. (which in future I propose to designate as *X*) corresponds very closely with *C*, and contains very few errors and interpolations. A very close examination led to the discovery of a few unimportant slips in vocalization which would hardly mislead anyone, and certainly not worth noting; and only one mistaken repetition (p. 46, l. 1). Although it is not safe to generalize from an examination only of one chapter, it appears that we have in this

1. *Ismaili Law of Wills*, 22.

2. For Idrīs b. Ḥasan, see Ivanow, *Guide to Ism. Lit.*, 62-65 and for *ʿUyūnu'l-Akhbār*, see *JRAS* for 1934, pp. 3-4 and the references there given. The *ʿUyūn* has recently been used by Gibb and Paul Kraus for their article on al-Mustanṣir bi'l-lāh in *E. I.*

MS. a very correct copy of the text of the second volume of the *Da'ā'im,* which after comparison with *C,* is likely to furnish valuable material for a fairly satisfactory text.

(The page and line refer to the text of the *Kitābu'l-Waṣāyā* to be found in Fyzee's *Ismaili Law of Wills,* Oxf. Univ. Press, 1933).

Page	29,	line	6.	Voc.	روينا (*ruwīnā*).
„	30,	„	12.	Read	عاهد (with *A* and *Mus.*).
„	32,	„	3.	Voc.	شهادة (as in text).
„	33,	„	1.	Read	بانك انت الله الذى (as in *Mus.*).
„	„	„	7.	Read	توفنيه .
„	„	„	8.	Voc.	يفرش فراشه (*yafrushu firāshahu*).
„	„	„	12-13.	Read	لاتخرجنّ الكذب من فمك ابداً .
„	„	„	14.	Read	تجترئ .
„	34,	„	5.	Voc.	فجهدك (*fa juhduka*).
„	„	„	6.	Voc.	تسرف (*tasraf*).
„	35,	„	6.	Read	ثم اخذ بيد ابن ابنه عليّ .
„	„	„	7.	Voc.	يا بنى (*yā'bnī*).
„	„	„	11.	Voc.	فلاتاثم (*ta'tham*).
„	„	„	12.	Read	اسماءَ الملوك في هذا الدنيا .
„	36,	„	8.	Read	ماجزي نبياً .
„	37,	„	5.	Read	ألا أبصر قبل (omitting ما with *A* and *B*).
„	„	„	9.	Read	و كيف لا تنصح من اخرجك .
„	„	„	12.	Read	أن تؤدّوا أجره .
„	38,	„	1-2.	Read	و من كان خصمه .
„	„	„	10.	Read (with *A, C, D*)	وحج البيت الحرام .

(I had omitted الحرام as the Qur'ānic verse omits this adj.)

Page 39, lines 4-5. Read و اوصيكم بقيام الليل من زوال الليل الى آخره، (There is no repetition as in *C*).

„ „ line 6. Read يعذر بالعذر.

„ „ „ 9. Read تناله شفاعته.

„ „ „ 9-10. Read او لا من أدمن شيئاً من هذه الاشربة.

„ „ „ 11. Read وهو اوجبهن.

„ 40, „ 5. Omit (with *C* and other ancient MSS.) وأطعموا الطعام. (I am now absolutely convinced that this is an interpolation.)

„ 40, „ 7. Read رجاء من أملكم فانّ ذلكم (*dhillu-kum*) اشبه بأنسابكم. (This makes much better sense, although *dhullukum* is preferable.)

„ 41, „ 3. Voc. واللهُ اللهُ (as in the text and in Lane, *Lexicon*, s. v. أله).

„ 41, „ 5. Read يستوحشنّ and ينصرفنّ.

„ „ „ 10. Voc. وهي (*hiya*) من بعد الى زوال.

„ 42, „ 4. Read فوجبت طاعته and ولاة الامر.

„ „ „ 10. Read وانتهوا الى نهينا (*nahyinā*).

„ „ „ 11. Read بأن تأتوا البيوت منها.

„ 43, „ 5. Read كرهه (*kariha-hu*).

„ 44, „ 2. Read من قضى نحبه وهم هؤلاء.

„ „ „ 3. Read وهوأنا و الله.

„ „ „ 9. Read و الدعوي قبلي على (*qibalī ʻalayya*).

Page 45, „ 2. Read وهوعبد وقد صيّرته اليك.

„ „ „ 5. Read و خيرمن أخلّف من اهل بيتي.

Page 45, line 10. Read فلك الحمد، عدد نعمائك لدىّ.

" " " 12. Read وحدك and لك and عبدك.

" 46, " 1. After 'المواقف, we have what seems to be a copyist's interpolation اللهم اجز محمداً عنا خيراً and then goes on as in the text: اللهم اجز محمداً عنا افضل الجزاء الخ.

" 46, " 4. Read حفظكم الله و رسول.

" " " 7. Omit (as in *B*) المعظم.

" 47, " 6. Read و عنه ع عن رسول الله صلع.

" 48, " 3. Voc. (with *C*) انه استحبّ (*innahu istaḥabba*).

" " " 8. Omits مالاً.

" " " 10. Read ذكرنا عنه.

" 49, " 5. Adds (with *C*) وعن على ص.

" " " 6. Voc. يردّ (*yaruddu*).

" " " 8. Voc. يترك (*yatruku*).

" " " 9. Read وعن ابى جعفر محمد بن على و ابى عبد الله.

" 50, " 5. Read (with *C* and *D*) جزء لفلان و جزء لفلانة.

" " " 10. Read (with *B* and *Mus.*) وكذلك الي العشرة.

" 53, " 6. Read الجنف.

" 56, " 7. Voc. يغرّم (*yugharramu*).

" 58, " 1. Voc. أستسعي العبد (*istus'i'l-'abdu*).

" " " 2. Read (as in the marginal gloss in *C*) أعتق (*u'tiqa*) العبد بالقيمة من الثلث ودفع (*dufi'a*) الفضل الخ.

Page 58, line 5. Voc. عَتُقَ (*'utiqa*).

Page 61, „ 7. Read والناظرمن لا ناظرله.

Page 62, „ 4. Read وعن ابى جعفر محمد بن على ع م انه قال الخ.

My friend Dr. U. M. Daudpota has been good enough to send me the following corrections to the text of *Kitābu'l-Waṣāyā* for which I am sincerely grateful:

Page 30, line 9. Read *dhālika.*

Page 37, line 9. Read *akhrajaka.*

Page 44, line 8. Read *allāhumma illā.*

Bombay, April, 1934. ASAF A. A. FYZEE

IDEALISTIC AND ROMANTIC ELEMENTS IN CONTEMPORARY BRITISH DRAMA *

I. 'Idealistic' and 'Romantic' defined.

II. Realism in Contemporary drama—its drawbacks.

III. The ways in which "Realism" is invaded and transformed by "Idealism".

(a) Strange settings; Shaw's *Captain Brassbound's Conversion* (1900). *Arms and the Man* (1898), *Caesar and Cleopatra* (1899), *The Devil's Disciple* (1901), *Back to Methuselah* (1921); Galsworthy's *Forest* (1924).

(b) Oriental Scenes: Flecker's *Hassan* (1914—Produced 1923). Lord Dunsany.

(c) Fanciful Situations: Barrie's *The Admirable Crichton* (1903); Arnold Bennett's *The Great Adventure* (1913).

(d) Remoteness of story and setting from present-day life: St. John Ervine's *The Lady of Belmont* (1924); Masefield's *The Tragedy of Nan* (1909).

(e) The Dream Play: Barrie's *Dear Brutus* (1914); *A Kiss for Cinderella* (1916).

(f) The Use of Symbolism in the Irish School: J. M. Synge's *The Shadow of the Glen* (1903); Edward Martyn's *The Heather Field* (1899), *Maeve* (1900); W. B. Yeats' *Cathleen Ni Houlihan* (1902).

(g) Premonitions: *The Riders to the Sea* (1904).

(h) An Eschatological play: *Outward Bound* (1923).

IV. Romanticism illustrated:

(a) Dream and Symbolism blended in a true romantic spirit: Galsworthy's *Little Dream* (1911).

(b) Irish Heroic Legend: J. M. Synge's *Deirdre of the Sorrows* (1910).

(c) Romantic treatment of literary biography: Clemence Dane's *Will Shakespeare* (1921).

(d) The Supernatural: Barrie's *Mary Rose* (1920).

I. When an artist selects and recombines scattered fragments from the heaving, surging, 'polyphonic, multi-coloured' world of his limited experience he introduces into them an element that transforms and renders them significant. This imaginative heightening and transformation of the crude elements of *felt* experience —'idealization' as we may call it—is the essence of art. Idealism therefore is a vital and integral element in all art, and as such the terms 'realistic' and 'idealistic' imply only differences of degree.

* The Drama of the last forty years. Poetic plays are not dealt with in this essay.— R. S. Aiyar.

When a writer swings away altogether from the common workaday world of getting and spending, sinning and serving, to a world of

"more pellucid streams,
An ampler ether, a diviner air,
And fields invested with purpureal gleams,"

where all earthly things are transfigured, we call his work 'idealistic'. If on the other hand, he is tethered to

"the tramp of the road,
The slave with the sack on his shoulders pricked on with the goad,
The sailor, the stoker of steamers, the man with the clout,
. . . .
. . . the maimed, the halt and blind in the rain and the cold,"

men, things and places in common everyday life—he is called 'realistic'. The terms 'realistic' and 'idealistic' refer, as the reader has seen, to the logical universe of 'content' or the subject-matter of a work of art. This brings us to that most confused adjective in literary terminology—'Romantic'. A play, poem or story may whisk us away from common human experience and yet remain thoroughly unromantic. The last scene of Shaw's dramatic saga of human progress, *Back to Methuselah,* conjures up the vision of human life as it may be in 31920 A. D.; when man by a prescient exercise of the "will to evolution" and by conscious control, through the ages, of the revolutionary urge in nature, is shown to have reached such a stage that a new-born baby will have the physical stature of a normal adult of to-day, while a child of four will possess the intellectual calibre of an Einstein. Yet in this highly *ideal* scene there is hardly a snippet of talk that can be called *romantic.* This takes us to the heart of the difference between 'ideal' and 'idealistic' on the one hand and 'romantic' on the other. What Shaw's scene lacks is the element of mystery, strangeness, magic and glamour, and iridescent suggestiveness. These are the qualities that can transform a common peasant girl's reaping song into wistful strains as of angels visiting the earth from a far-off realm of light and joy:

"A voice so thrilling ne'er was heard
In spring time from the cuckoo-bird
Breaking the silence of the seas
Among the farthest Hebrides."

Here is wizardry. What accomplishes it is colourful, prismatic diction with the penumbra of dim meanings. Where the images are clear-edged and the words carry with them a sharp outline of meaning, where every incident narrated stands out in definite outlines and the background is perceived with a transparent dis-

tinctness that doesn't stimulate the imagination to strain for the vistas, the visions and the shadows beyond the picture, we have 'classical' art. In other words, 'classical' and 'romantic'—as distinguished from 'idealistic' and 'realistic'—refer to the style and form of a work of art, and are antithetical terms. We differ, therefore, from Professor Abercrombie when he speaks of this antithesis as wholly improper because, according to him, "classicism is of a quite different order of things from romanticism."[1] The crucial difference between the two terms is finally hit off by Sir Sidney Colvin in his introduction to his *Selections From Landor*.[2]

"In classical writing every idea is called up to the mind as nakedly as possible, and at the same time as distinctly; it is exhibited in white light, and left to produce its effect by its own unaided power. In romantic writing, on the other hand, all objects are exhibited as it were through a coloured and iridescent atmosphere. Round about every central idea the romantic writer summons up a cloud of accessory and subordinate ideas for the sake of enhancing its effect, if at the risk of confusing its outlines. The temper, again, of the romantic is one of excitement, while the temper of the classical writer is one of self-possession. No matter what the power of his subject, the classical writer does not fail to assert his mastery over it and over himself, while the romantic writer seems as though his subject were ever on the point of dazzling and carrying him away. On the one hand there is calm, on the other hand enthusiasm, the virtues of the one style are strength and grasp, with clearness and justice of presentment; the virtues of the other style are glow of spirit, with magic and richness of suggestion."

II. The significance of idealistic and romantic tendencies in contemporary drama can be better appreciated if we recapture and fix in our minds the character of latter-day realism on the stage. For all their conscientious desire to give us the tang of common life in its ceaseless grind and attrition,—life as lived in a slum-tenement, in a suburban boarding house, in a factory or middle-class drawing-room—for all their masterly technique, compression and suggestiveness of dialogue, very few modern realistic plays, perhaps not more than a score, can take rank as supreme interpretations of life and character. Ibsen's *Peer Gynt* and *Brand* and *Rosmersholm* not only stormed our imagination when we first read them but compelled us to return to them for fresh insight into unperceived significances. How many plays of the last two decades can challenge comparison with them? If the history of criticism has proved any one thing it is the amazing ineptitude of contemporary judgments. Our en-

1. *Romanticism*, p. 31.
2. Pp. vii and viii.

thusiasms and aversions are alike proved wrong, in most cases, by remote posterity. The myopia and astigmatism to which contemporary criticism is subject should make us cautious in singling out the plays of our time that appear in our estimation to bear the hallmark of excellence. Galsworthy's *Loyalties* will always grip us with its subtle and profound study of the motives that impel to crime a distinguished army officer normally inclined to probity and rectitude, with its study of conflicting loyalties, and its tense progression through scenes of pathos, suspense and surprise. So will *The Skin Game,* in which through scenes of tension surprise treads on surprise, but in obedience to the logic of character and initial circumstance. Who can forget the delirious excitement of the two bidders in the auction scene or that other in which Chloe, in frantic endeavour to conceal her seedy past from the world, offers herself to Dawker by way of hush-money—a scene that reveals her quick transitions from wheedling to reviling, from wrath to appeal, the rapid chase of emotions and the lightning play of mind? Again one loves to recall St. John Ervine's *John Fergusson,* a consummate study of the tragic aspect of life, of the way in which circumstance, conspiring with character, deflects 'the arrow that flies in the dark' and makes it strike the wrong person. Its characters John and Sarah Fergusson, Andrew, Hannah, Clutie John and Jimmy Caesar—are drawn with such splendid vitality that Pirandello could make them the central figures of another *Six Characters in Search of an Author.* By the side of these plays may be arrayed the same playwright's *Jane Clegg,* Sean O'Casey's *Juno and the Paycock,* Eugene O'Neill's *The Hairy Ape,* Harold Brighouse's *Hobson's Choice* and a dozen more, perhaps, according to individual preference. But a great many of the Yorkshire and Lancashire plays that blazed a trail in modern realism and embodied an admirable and even flawless craftsmanship, like Githa Sowerby's *Rutherford and Son,* St. John Hankin's *The Return of the Prodigal,* Stanley Houghton's *Hindle Wakes,* Somerset Maugham's *The Circle* or Elizabeth Baker's *Chains,* C. K. Munro's *At Mrs. Beam's,* which appetized us as we read or witnessed them, do not make us wish for a second 'go'. The realism of the uncompromising sort that demands the Fourth Wall on the stage is almost played out and finds itself in a blind alley—played out, because of an inherent but not incurable drawback, which may be stated in Mr. Herbert Read's words: "Modern Drama lacks the power to transmute its materials; it burns at a low temperature and with little light; it does not lift us into that other world which is the world of imaginative logic."[1] Modern Realism, again, is not all an approximation to reality. As Sir John

1. *Reason and Romanticism,* p. 125.

Squire observes somewhere, it has substituted "a novel set of conventions for a set of which people had grown tired. West End drawing rooms were replaced by homes of suburban clerks; rosy sentimentalism was replaced by cynicism, a prophetic pessimism or a detached irony of presentation; speeches gave way to silences or pregnant ejaculations . . . ."

III (*a*) We do not suggest for a moment that the return of major inspiration to the stage will be effected by a return to idealism or any other 'ism'. Genius always struggles to free itself from the Procrustean bed of literary fashions. Even if such a struggle does not end in the attainment of great art, the struggle is significant of dramatic originality, adventure and initiative. The pull against realism in different directions, noticeable in contemporary drama is an index of its vitality, a clue to its protean variety and complexity, and an attestation of the fact that literature that is really alive refuses to be catalogued under ready-made labels. In fact, in attempting an analysis of the idealistic and romantic tendencies in modern drama we are only trying to comprehend it from an unsophisticated point of view. It is interesting to mark the spell that the wild, the far-off and the picturesque—whether in respect of characters, setting or situations—have exercised on several of our writers. The scenes, for instance of Shaw's *Captain Brassbound's Conversion,* laid in a Moorish castle near the Atlas Mountains, have for hero a Byronic adventurer surrounded by his desperadoes, and for heroine a lady of rank, who, by her courage aplomb and charm, not only disarms wild Shaikhs and Cadis but rescues the melodramatic Captain from himself. *Caesar and Cleopatra* opens in the Egyptian desert, with the sphinx in the foreground, the scene slowly brightening in the growing dawn and, anon, becoming vocal with the soft strains of Memnon's harp. In *Androcles and the Lion, Arms and the Man, The Devil's Disciple* and *Back to Methuselah* Shaw takes care to sustain the vivid spectacular interest of the audience. Galsworthy, generally austere and puritanical in this respect, more than once sends his severe virtues whistling down the wind. Reminiscent of Conrad's *Typhoon* and *Victory* are the middle scenes of *The Forest,* picturing the central African jungle, in which nothing is so ugly as "the visible, selfish rush towards the sky, the uproar of the rush, and the fierce, heartless jostling and trampling"—nature red in tooth and claw and emblematic of the infernal financier, Bastaple, and his unholy agent, Strood. The romantic love-story of the naturalist (Herrick) and the half-caste girl (Amina) have a remote resemblance to that of Axel Heyst and Lena.[1] Flecker's *Hassan* (posthumously

1. Conrad's *Victory.*

published in 1922), in spite of its climactic torture-scene striking the true Websterian note of horror, owed its popularity when first staged to its remarkable evocation of the Oriental atmosphere. The play, crammed with metaphors and turns of speech struck off, with the ease of poetic genius, as from an Oriental anvil, mirrors the character and temper of the Moslems of the Middle East; and for sheer atmosphere this sensational piece can challenge a place by the side of *The Talisman* and *Hajji Baba of Ispahan.*

(*b*) The great specialist in Oriental atmosphere is, however, Lord Dunsany. The bizarre and the creepy are his native element. In *The Gods of the Mountain* (1911) Agmar, an old beggar, with no mean histrionic talent in him, influences his servant and five other beggars to pose as the presiding deities of the city, whose effigies, carved in jade, crown a neighbouring mountain-top. The citizens come and prostrate themselves before the beggars. The vague and formless fear in the hearts of the beggars (except Agmar) and their devotees gather shape in the scene until it mounts up to a climax of petrifying horror when the gods themselves emerge on the scene to punish the outrageous simulation of themselves by the beggars.[1]

(*c*) In several modern plays novel setting and fanciful situation are employed either singly or together as an effective stalking horse for social satire. Outside the Shavian canon (which specializes in this art) the best illustration of this is *The Admirable Crichton* (1903). Sir James Barrie employs in it Shakespeare's pet device of the shipwreck in order to strip off from his characters the trappings that cover up their innate worth or baseness, and, by depriving them of all adventitious advantages of birth and wealth, exhibit them amidst conditions where only native genius or talent can avail. The piece is a merrily wicked skit on the English aristocracy, cross-lighting from a new angle its degeneracy of soul; and through it, like an under-chord, runs an implicit criticism on the inversion of values in a decayed society—Crichton's dictum, "circumstances alter cases", being a minatory warning for Loam and his progeny. Differing, as *The Admirable Crichton* does, both in scale and method, from Shaw's *Back to Methuselah,* they have a common aim—the criticism of sham values in 'civilization' in the light of an ideal envisaged in a remote point of time or space.

Another striking illustration of this 'topsy-turvy' method is *The Great Adventure* of Arnold Bennett (produced in 1911, but dramatized from an earlier story, *Buried Alive,* 1908). The story of the greatest painter of the age impersonating his own valet

1. For *A Night at an Inn* (1916) and *If* (1921) see Allardyce Nicoll's *British Drama*, pp. 420-423.

in order to escape the dogging wraith of fame, and its offspring—the prurient curiosity of the public—and so finding love and happiness in a humble cottage in Putney, is not only a clever vehicle for an implicit sermon on the secret of true happiness but also a weapon of withering satire on British national camouflage, philistinism, snobbery, the fussiness of lawyers and journalists' craze for 'scoops' and scandals about public men. The fourth act in which several inconsequent details mentioned in the first swim up into dramatic significance is a study in the art of suspense.

(*d*) Neither reformatory nor satiric purpose governs St. John Ervine's *The Lady of Belmont* and Masefield's *The Tragedy of Nan.* Purporting to be a sequel to the *Merchant of Venice, The Lady of Belmont* unfolds the lives and fortunes of Shakespeare's characters after the escape and discomfiture of the trial scene and the lovers' first rapture of union. It is not a play that Shakespeare could have written but did not,—but one that Shakespeare did not because he could not. The modern playwright, reading between the lines of character, evolves his own Antonio, Bassanio, and Shylock, not along the lines of Shakespeare's inclination, but along the *logic* of his hints and outline. *The Lady of Belmont* fulfils Shakespeare in a manner that would have amazed even more than amused Shakespeare. Bassanio who had no compunction in making his dearest friend sign a perilous bond, merely because he wanted to marry "a lady richly left," develops here into a full-fledged rake. Antonio who could be insolent even when seeking Shylock's favour and almost cringe to him when the prospect gloomed—"Hear me yet, good Shylock, I pray thee hear me speak" who could "pray God, Bassanio come to see me pay my debt" (and then "he would care not"), appears in St. John Ervine's piece as an insufferably tedious harper on Portia's and Bassanio's obligations to himself. Antonio feels a succulent pleasure in recalling the memory of everybody he meets to his generous act of a decade since. He is shocked by others' ingratitude. While he shows himself as the true Jew, Shylock reveals himself as the true Christian. He has forgiven and forgotten and learnt the gospel of love: "I know that outward things pass and have no duration. There is nothing left but the goodness which a man performs," he tells Portia. Understanding the strength of his race he has penetrated to their weakness too: "We are a proud and narrow race, and our pride and narrow minds have ruined us. I have the power to govern men.........My heart stirs when I think of generous government and of kindly races striving each with each for greater love and beauty and finer men and women. But I am condemned, because I am a Jew, to be a usurer and spend my mind on little furtive

schemes for making money." In the same scene we have the psychology of his former hatred for Antonio: "Revenge! When I sought Antonio's life I was a bitter-minded man, and cherished hatred in my heart. Sometimes still I am full of anger when I hear my race derided. What have we Jews done that we should be loathed and mocked by all mankind." Portia's little kindness so touches him that without her knowledge he lends her money through cousin Bellario—this, even when he knows she was the judge who smashed his suit against Antonio. Later, when he has seen the intrigue between Jessica and Bassanio, he takes her (Jessica) with him to Venice so that Portia's home-life may be less unhappy. "Sufferance is the badge of our tribe"—says he in Shakespeare's play; in St. John Ervine's, understanding, self-criticism and humanity are shown as the attributes of that 'Sufferance'. With Bassanio for husband how do we expect Portia to shape? She has lost her decisiveness of character and gained a sad, indulgent wisdom for others' foibles and the realization that life is a *pis aller*.[1]

The Tragedy of Nan is an experiment in quiet and subdued beauty of dramatic art, a beauty that transfuses itself, like pollen dust in the spring air, through setting, character and style. The idyllic rural landscape is vocal with the murmur of the Severn, and the air throbs with vague supernatural presentiments towards the close. The style, if occasionally a little studied, has the quality of fine filigree-work

"Fashioned so purely
Fragilely, surely"

—its gamut ranging from a lover's tenderness to a Fury's wrath. The noble simplicity and sensitive restraint of Masefield's art in this tragedy demand something of histrionic genius to make it a success on the stage.[2] Nan, drawn in vivid and subtle strokes, seizes our imagination and fills the foreground. Intensely passionate in love she is not less so in her hatred of gad-about wantonness given to trifling with the human heart. Endowed with a sensitive pride that worships the memory of a father hanged on a false charge of sheep-stealing, she yet could fling aside her forbearing meekness and hit back when his memory is insulted by her churlish aunt. The callous meanness of her cousin (who would treat Gaffer Pearce to pies of

1. In Gordon Bottomley's *Gruach* we have a similar but lighter essay in Shakespearean interpretation. The piece depicts Lady Macbeth as an eager-hearted and ambitious girl before she hardened into the terrible figure of the tragedy. But *King Lear's Wife* develops the characters of Lear, Goneril and Cordelia along fanciful lines.

2. *Cf.* A. C. Ward: *Twentieth Century Literature*, pp. 98-99,

tainted meat) provokes the dormant hell-cat in her. The glancing lights of Nan's many-sided character converge into a burning focus in the scene where after describing the money sent to her by the Home Office by way of compensation for the judicial murder of her father as "some blood-money—thirty pieces of silver," she hands it over to Gaffer for the headstone he had been longing for years to erect at the grave of his wife. Frank, fearless and yet tender-hearted, with a deep-seated poetry in her nature, she is depicted as combining the wisdom of the serpent and the innocence of the dove.[1] As the tragedy draws to a close a calm resolve to die takes possession of her—to die, but not before punishing the libertine who has toyed with her love. She kills him not so much to feed fat her own grudge, but in order that she may save other women from becoming his victims. The quivering tenderness of the scene between Nan and Gaffer Pearce, has no trace of mawkish prettiness about it, and exemplifies the classically controlled strength of an art that can touch the soul while keeping the sentimental at arm's length.[2]

There is, however, a loose joint in the structure of the play: the scene in which Pargetter, instead of asking Nan a straight question about the broken toby-jug, hedges about, whereof St. John Ervine, hitting the bull's eye, remarks: "he does not so, because Mr. Masefield wishes to alienate him from Nan, and cannot cause the alienation without a misunderstanding that is more appropriate to farce or sentimental comedy than tragedy".[3]

(*e*) The character of Realistic drama suffered a sea-change when Barrie invaded it with a genius that lightly doffed—or, as in *Alice Sit by the Fire,* made light play of—dramatic fashions. In order to whip off the pall of familiarity from souls whose inmost character and aspirations are hidden by the smoke-screen of circumstance, and to render audible the heart-throbs beneath the human debris, Barrie employs romantic machinery with a lavish hand—the supernatural, dream and symbolism—and so boxes the compass of a method of which Maeterlinck is the acknowledged master on the Continent. But in spite of the enormous wings that grow from his shoulders his feet are securely planted on right earth. The dream symbolism in *Dear Brutus* diffracts the abstract truth embodied in the Shakespearean line, " The fault, Dear

1. Mr. St. John Ervine regards this as an inconsistency in characterization: "Nan speaks with two tongues, the tongue of a young innocent country-girl and the tongue of a woman of much knowledge and experience". *How to Write a Play,* p. 108.

2. C. E. Montagu's admirable criticism of this play in *Dramatic Values* may be read with profit.

3. *How to Write a Play,* p. 108.

Brutus, is not in our stars but in ourselves that we are underlings." To drifting ennuied people the return of a lost chance would not come as a tidal wave to float them to brilliant successes in the moral and intellectual sphere, nor bring sovereign moments for regaining lost heights, but would simply make them retread the same futile road. "What really plays the dickens with us is something in ourselves. Something that makes us go on doing the same sort of fool things however many chances we get." The hypnotist of this Modern Midsummer Night's Dream, Mr. Lob, sends his guests for a stroll into "the magic wood" of his witchcraft. Purdie, an Oxonian and sometime aspirant for the presidentship of the Union, re-traverses the same old primrose path of dalliance. Coade, the uxorious husband who has always been speaking of *finishing* his *magnum opus* on the *Feudal System* and never of beginning it, becomes a jolly bachelor, piping and pirouetting and clean forgetting his wife. Maty, Lob's butler, turns out the fat-paunched financier of his dreams. The crapulent, gone-to-seed Dearth, who has long survived his ambitions in art, finds joy in the company of his dream daughter (Margaret), while his wife, with her lustrous eyes and smouldering passions, marries the lover of her aspirations, the Hon'ble Finch Fallows, only to be deserted and rescued from hunger by Dearth and Margaret.

Barrie's elvish art dislimns the solid realism of the opening scene into the mischievous air of the eerie wood and re-crystallizes it into the initial tangibility. Admirable is the naturalness with which the human mosaic, pulling itself to pieces, rearranges them into the quaint patterns of the might-have-been, and then restores itself. The magic wood not only illustrates the futility of a second chance but also the working of "the unconscious," in ways possible to the theatre but not to the analytical psychologist.

A Kiss For Cinderella portrays cockney imagination, the mind of a London waif, who fancies herself to be Cinderella.. Her dream is a composite of the *disjecta membra* of her waking experiences and imaginings. "The Times," a name she has frequently heard in War time, incarnates itself as Lord Times, the most formidable nobleman in the King's court, and by his side is the grim executioner, the Censor. The King and Queen, attired exactly as in playing cards, hold on to straps suspended from overhead; for strap-hanging has been a rare privilege to Cinderella; and their thrones are very much like the seats in a Tube train. The rival princesses prance round him like high-stepping steeds; their merits are tested by means of thermometers, the winners bearing prize-cards as at a horse-show. The Prince Hard-To-Please, who rejects them mercilessly, only to succumb to the fasci-

nation of Cinderella's peerless feet, is dressed like a pantomime figure and has a face suspiciously like that of the policeman who loves her. Meanwhile the king exclaims, "The fire in the stove is going low," whereupon it is made to blaze up with a shilling instead of a penny in the slot. The happy couple are married by a penguin, Cinderella having been once told by a benefactor that 'penguin' meant a bishop. The Prince and she then dance the fox-trot.

The dream-fabric is the compensation that the 'Unconscious' evolves for the deprivations and frustrations of life. In the meanest there is an assertion of self-respect and vanity, a hunger to give and receive love, and a suppressed yearning to witness and be the central figure of pomp and glitter beyond their reach. It is this longing for the world's tinsel and the heart's gold that finds expression in Cinderella's dream.[1]

(*f*) In several realistic plays of the Irish school is heard the call of the wild, of moorland, mountain and sea, and, in a few, something rarer far than these, namely the yearning after

> " Lost lands, lone seas, lands that far agleam
> With a miraculous beauty, faint yet clear,
> Forgotten lands of night and star-gleam,
> Seas that are somewhere but that are not here."[2]

This " call of the wild " we have spoken of finds the best illustration in J. M. Synge's earliest play, *The Shadow of the Glen.* J. M. Synge worked with the conscious aim of reacting against the art of Ibsen and Zola who, he said, dealt with the reality of life in joyless and pallid words,[3] " and by the presentation of what is superb and wild in reality " he sought to bring a richer joy to the stage than Ibsen and Zola knew. As Synge's view of Ibsen was wrong so was his work far from embodying that joy he quested after, but he achieved something new and original, a gripping synthesis of pity and irony, poetry and farce, disillusionment and aspiration, stark realism and romantic beauty. An invalid with a craving for life piping hot, a super-tramp like W. H. Davies and Masefield, Cunninghame Grahame and Stella Benson, he makes us hear in everyone of his plays the whir of adventurous wings: " Clay lies still, but blood is a rover." In *The Shadow of the Glen* Norah Burke has the same fascination for the wild moors that Ibsen's Ellida Wangel has for the sea[4] and Bell Haggard (in W. W.

1. Contrast Hannele's Vision of Jesus and chorus of angels from 'the realms of light' in Gerhart Hauptmann's *Hennele.*
2. Sir John Squire's *Town.*
3. Vide Preface to J. M. Synge's collected works (Maunsell).
4. *Cf.* also Guy Font in Edward Martyn's *An Enchanted Sea.*

Gibson's *Krindlesyke*) for a life of hazard. Like Nora, Deirdre (in *Deirdre of the Sorrows*) spurns a kingdom to go salmon-spearing and roaming with the sons of Naisi.

The eerie spell that the heather field exercises over Carden Tyrrell, in Edward Martyn's play (of that name) is but the symbol of that immortal beauty half-revealed and half-concealed by the imperfect vesture of Nature—the starry firmament, the earth and the sea. In mountain breezes he hears "the choristers singing of youth in an eternal sunrise." This sublime passion in Tyrrell becomes tragic when it makes him mortgage his land to drain and fertilize the tracts subjacent to the heather-field, so that the value of the heather-field may double itself. He refuses to listen to wiser counsels and flings all his money into the maw of this wild-cat enterprise, until he ruins himself. The tragedy of his life is intensified by the antipathy of a thoroughly prosaic wife to whom his spiritual passion—for such it is that prompts the enterprise—is but mid-summer madness. Maeve O'Heynes (in *Maeve*) is a nympholept of this longing for the dreamland of ideal beauty—of which Tirnan-Ogue, the land of everlasting youth and joy, in Celtic mythology, was but the emblem. Maeve sees her mystic love as an "exaltation from the earth to the stars." The ancient glory and beauty of Eire (Ireland), alike of her heroic past and of her landscape, are summed up to Maeve in the legendary figure of Queen Maeve, whom she sees in vision and whose voice she hears, beckoning her to a "land of rest without pain or fear of bondage—rest in beauty which is transcendently cold."[1]

In W. B. Yeats's *Cathleen Ni Houlihan* it is not this light of lights but the personified Spirit of Ireland who visits a peasant (Michael Gillane) in his cottage at Killala, in the guise of an old crone, and fires him with patriotic fervour. She comes with a moving tale of sorrow and says: "If any one would give me help he must give me himself, he must give me all." Michael, on the eve of his marriage to a lady of his choice, is enthralled. At this juncture, a shout outside announces the landing at Killala of the French who have come to help Ireland against the English. Michael breaks away from the arms of his bride entreating him not to leave her, and goes out beckoned on by the voice of Cathleen who has become meanwhile miraculously transformed into a youthful maiden.

In all these plays, apart from their symbolism, the starry passion for an ideal paves the way to the hero's ruin, exemplifying

1. *Cf.* Mary Bruin in W. B. Yeats' *The Land of Heart's Desire*, and Barrie's *Mary Rose*.

one of the essential features of tragedy and the source of tragic pity—the spectacle of greatness brought to heel by its own lop-sidedness.

(*g*) J. M. Synge's *The Riders to the Sea* illustrates another element of idealization. More a threnody in dramatic form than a tragedy in the strict sense, Synge's piece is, like Maeterlinck's *L'Intruse*, a *tour de force* of expectant dread and imaginative awe, and holds us in its weird grip to the last even though we have anticipated the conclusion since we became alive to the ominous significance of the boards bought for Michael's coffin. Maurya is indeed a figure of sombre majesty whose concluding utterance, striking a note of grim fortitude and calm wrung out of a life-time of woes, subdues us with the awful power of one who, unpetrified, has looked the Gorgon in the face.

(*h*) A play, as we have remarked at the outset, may deal with a phantom-world and yet be thoroughly diaphanous and devoid of atmosphere. Sutton Vane's eschatological *Outward Bound* is one of the best illustrations of this. Its value lies mainly in its inner meaning that the world towards which man voyages after death is so constituted as to provide for his future evolution. It enables him to shed his past through suffering, to learn the lesson of love and self-sacrifice, to find fresh fields for his activities—if they have been inspired by right motives. It is a world where the First becomes the Last, and values are reversed. The diversities of man's moral and spiritual nature are diagrammatically represented by a swindler—an ex-M.P. much esteemed while on earth—a suicide, a char-woman whose instincts of love and protection had to be smothered while in the flesh, a scheming woman, a kind-hearted tippler, a weak doting couple who have committed suicide through lack of courage to face up to life, and an earnest-minded humane clergyman. These souls are "outward bound," voyaging on a phantom-ship towards the unknown. A realistic play with an idealistic significance; but, that the playwright has lost a great opportunity is clear towards the close.

IV. (*a*) Galsworthy's *Little Dream*, in which there is no external action, strikes the true 'romantic' note, of glamour and the beckoning towards vague hinterlands of imagination. The artless Swiss maiden, Seelchen ("Seelchen" means the " Little Soul "), is wooed in her dream by three alpine peaks, The Cow Horn, The Wine Horn and The Great Horn. The Cow Horn symbolizing the spirit of the mountains, is attended by the Flower-sprites, the grey white edelweiss, the blue gentian, the yellow mountain-dandelion and the pink alpenrose, all gemmed with dew drops that ring like little bells.

"Come to see me," says the Cow Horn, "Stalk the eternal hills—I drink the mountain snow. My eyes are the colour of burned wine; in them lives melancholy. The lowing of the kine, the wind, the sound of falling rocks, the running of the torrents: no other talk know I. Thoughts simple and blood-hot, strength huge—the cloak of gravity. Live with me under the stars, I shall wake thee with crystal air." The Wine Horn, on the other hand, beckons the Little Soul with a youth's voice to the city, to the will-o'-the wisp that dances through the streets. "In white palaces I dwell and passionate dark alleys," he says. "The life of men in crowds is mine—of lamp-light in the streets at dawn: I have a thousand loves and never one too long . . . I drink the wine of aspiration and the drug of disillusion." To the maiden torn between their antiphonal voices of society and solitude, of work and peace, of aspiration and contentment, comes the call of the Great Horn—the mountain of final Mystery and Providence; "Burn on—thou pretty flame, trying to eat the world; Thou shalt come to me at last, my Little Soul!"

(*b*) Deirdre, "the Helen of Irish heroic legend," has always haunted the imagination of Irish poets and dramatists. In dramatizing her story J. M. Synge was but following in the foot-steps of Yeats and "A.E.", Thomas O'Kelly, Sir Samuel Fergusson and Eva Gore-Booth. In spite of its pervading feeling for Nature, the exuberance and cadence of its language,[1] and its romantic wistfulness—all reminiscent of Ossian—*Deirdre of the Sorrows* stands out as one of the most Greek of Irish plays. As in *Agamemnon* and Synge's own *The Riders to the Sea*, here, too, are audible the rumblings of the coming doom. Deirdre herself is drawn, to quote Mr. Maurice Bourgeois, "not as a queen but an untamed, unsophisticated child of nature" brought out of "the land of mystic visions, where poets like Mr. Yeats and 'A.E.' seemed to confine her, into the world of flesh-and-blood reality".[2]

(*c*) Literary biography has also contributed its own grace-notes to embellish the romantic "harmony". In *Will Shakespeare* "Clemence Dane" resurrects the atmosphere of the Elizabethan age

1. The wonderfully rhythmic speech that so charms the reader of Synge's plays and annoys their spectator are an imaginative re-fashioning of phrases and words, redolent of Elizabethan English and the Bible, heard and carefully stored up in the memory by the gipsy-minded author as he stayed with that purpose among the Aran islanders. Their language is Elizabethan in framework, Gaelic in idiom, copious in curious inversions, cumbered with expletives (like 'it' and 'itself' and 'be' in wrong places) and formless in syntax. It is a gorgeous and quaint apparel that hampers the movement of the play on the stage—a thing of beauty, nevertheless a continuous irritation and misfit on the stage.

2. *John Millington Synge and the Irish Theatre*, p. 215.

with its roistering good spirits, its worship of the glory of words and metaphors. Its apotheosis of the sovereign, its adventurousness and its newly-awakened national consciousness. The play is resonant with Shakespearean echoes and turns of speech, and achieves a happy fusion of scholarly imagination and passion. It is based on Frank Harris's theory that Mary Fitton was the faithless dark lady of the sonnets. Shakespeare hears the mysterious call of London and the voices of his unborn children—Juliet, Rosalind, Ophelia, Desdemona, Macbeth, Othello and others—and leaves Anne Hathaway without any qualms for her having inveigled him into marriage with the pretence of expectant motherhood. Against her piteous entreaties born of a wild hunger for his love he stops his ears. When he is inexorable the wife bids him remember her, were he ever to heave sighs of unrequited passion for another—and were he ever to find himself betrayed into a "deed he would not do." Her prophecy is fulfilled. Shakespeare fares forth to London, is caught in a singeing passion for the flighty Mary Fitton. To convince her that he could create something better than the gossamery *Midsummer Night's Dream,* he writes *Romeo and Juliet* palpitating with his own heartache for Mary. After ecstatic scenes with Mary playing the role of Juliet follow the quarrel between Shakespeare and the new rival for Mary's love, Marlowe,—a quarrel that ends in Shakespeare killing Marlowe. Every casual word of his discarded wife now comes home to him with the import of an awful nemesis. "He has done the deed he would not do,"—indicates the geometrical symmetry of the play.

(*d*) Barrie's *Mary Rose* gives us the breath of romanticism *in excelsis.* The hue and fragrance of this play lie for the most part in its deftly changing tones, overtones, and contrasts of atmosphere. The crepuscular grey of the prologue scene abruptly changes, as by the waving of a wand, into the vivid warmth and brightness of an English home, that deepen to their acme in the subdued thrills of love and laughter on the elfin isle. Not only is this central scene taut with suspense, like the opening one, but becomes towards the close, through Cameron's story, the ecstatic ejaculations of Mary Rose and every word of the lovers' talk, terrible with a steadily gathering groundswell of tragic irony. The island begins to weave its weird spell around us, whether reading or hearing; and we gradually yield to its dark fascination. Barrie has invested airy nothings with form and power such as they rarely acquire in poetry or drama. Then by a sharp turn we are again in pensive dusk, not devoid of bright streaks—in the home of the aged Morlands who have drowned old sorrow in love. This shortlived evening glow rapidly fades into the sable of the epilogue scene,

But it is a gloom that ushers in the stars of man's far-off Hope. As the curtain drops, we have passed in review three generations of joy and sorrow—a strange tapestry of bright and sombre colours, such as De Quincey gives in *Suspiria de Profundis,* has unrolled itself before our eyes, filling us with the pathos and mystery of our lives.

The play is a fairy fabric of grey mist and cloud, sunshine and rainbow, raised by thaumaturgic art—a wonderful tissue of sentiment and humour, irony and pathos, comedy and tragedy, nature and fireside humanity; of ghost and enchantment, of eternal youth and age; and running through this chatoyant web of silver and grey, and shades between, are threads of mystic meaning. It is an efflorescence of Celtic genius at its finest—for who else but a Celt can transmute to such purpose Celtic legends about a fairy island?

If the supernatural is the life-blood of *Mary Rose,* its soul lies in its subtle, elusive meaning, which led its first audience at the Haymarket theatre such a dance. Eternal youth, granted to Mary Rose, does not ensure her cloudless, final peace and joy. Attachments of "the darkling earth"—of husband and child—drag her back to her old home, only to beget fresh disappointment and leave a void in her heart. Her perpetual youth, in spite of the magic island, is after all of this world and partakes of its imperfection. When Rip Van Winkle wakes up old and hoary after his long sleep he finds himself an utter stranger in a new world that knows him not and can only stare at him. Mary Rose returns to her old home, clothed in the vernal freshness of fadeless youth, only to find that what to her has been a blessing so long is now only a barrier between herself and her dear ones; her yearning for the child torn away from her bosom becomes a fatal flame. Now that she finds the object of her long search we expect the scene to close in maternal raptures. But the heartache of the tossed soul does not cease and is appeased only by its turning towards its Fount of Splendour. "Naught of earth—even eternal youth—can satisfy the soul's craving," is the esoteric significance of the play.

Barrie's first raid into the supernatural was the one-act piece, *A Well-Remembered Voice.* Barrie's ghosts show a forgetful mind and a far-off, abstracted interest in persons once dear on this side of the gulf. His Mary Rose is a wistful phantom with unstilled yearnings and lingering embers of old gaiety—a remarkable projection of incorporeal personality. The garrulous and vivacious Dick of *A Well-Remembered Voice* is a blend of mystery and realism, an enigma of detached feelings. Through him Barrie makes us see that the values of "the dead" are not those of "the living" and that they look on men and things with other and renewed eyes.

Dick does not care to appear to his mother who is pre-occupied with séances, but to the sceptical inwardly-stricken father, to cheer him up. The play is also interesting as a sly satire on crude spiritualism that was a craze with many during the War.

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R. SADASIVA AIYAR

NOTES ON THE NATURE OF 'LITERATURE'.

"When I use a word," Humpty Dumpty said in rather a scornful tone, "it means just what I choose it to mean, neither more nor less." "The question is" said Alice, "whether you can make words mean so many different things."

—THROUGH THE LOOKING GLASS, p. 125.

In discussing literature, people frequently make the mistake of doing so without any clear idea of what it is that they are discussing. Therefore, I shall here proceed quickly to a definition, which exigencies of space will not permit me to defend or explain categorically, in order that what follows may be clear.

Printing and popular education have, with the passage of time, increased the number of books more enormously than even the Preacher foresaw, and have forced into lively existence the specialized essay and the historical conspectus of literature. It is greatly to the credit of literary historians like Saintsbury and Professor Elton, that they have so well maintained appreciation of individual pieces, and to the credit of some authors of individual studies, that they have not forgotten the importance of period and influence as aids to understanding. Nevertheless, it is not schools, periods, or influences, nor even authors, which present themselves to us, but pieces of writing. In what period, under what influence, and even from what author, a piece appears, are not the first things, but are brought in either to aid understanding, or for convenience in description, for which purposes their value is inestimable; but they lead to confusion if they are allowed to take precedence over the single piece as the object of our thoughts about literature. The niceties of detailed scholarship, and the panorama which wide learning gives, are of the utmost value as aids to the appreciation of literature, but they are not substitutes for it. That they may serve their proper purpose, they must be preceded by some implicit or explicit notion of what literature is and does; otherwise, not only is there confusion, but judgment is made impossible.

Literature I define as '*that which produces immediate pleasure in its reader*'. The purpose of this is not to lay down a law, but to indicate a basis for this discussion. Pleasure has ever been held an essential part of literature. I say '*immediate pleasure,*' because what is not read to that end, is not read as literature, but for an

ulterior motive. I say '*in the reader*,' because literature presupposes a reader, because the pleasure which the author takes need not bear on the piece, considered as literature, and because the pleasure which publisher or bookseller or anyone else has in it, is quite beside the point. Further, not only has the author's pleasure nothing to do with it, but neither have his intentions, necessarily, except in so far as they are presented to the reader in the piece, which is the only thing that directly concerns the reader. This is to say that writings are to be viewed first as affecting readers; not as the productions of minds, but as their objects.

Much confusion of thought results from failure to perceive and practise the validity of one all-important distinction; that is, the distinction between literature and life, and while we often pay it lip-service, its bearing on other matters, in practice, we continually forget.

The human race owes its commanding position among animals to its adaptability, which, in turn, it owes to its ability to acquire and apply knowledge. Not only is an intelligent child inquisitive, but also an intelligent man or race. That into which we inquire is the circumstances of life, in order to establish a satisfactory set of relations between ourselves and the things which surround us. Words serve humanity as conveyers of information, and writing as its store-house. The successful pursuit of inquiry, like the successful discharge of other natural functions, is a source of pleasure to mankind. But as well as their literal significance, their core of universal meaning, words have emotional power, the product of association and suggestion, which vary a great deal with the person. Yet, if one looks more deeply into it, this quality of words does not really differ from their quality of significance. The emotional reactions which they produce, the ideas they call up, and the things they suggest, besides their literal significance, are part of the meaning of the words. And the total amount, as it were, of significance they have, both the literal and that which is added, depends largely on the success with which they take up relationships and fit into their place in the mind. And this in turn depends on the stock of knowledge in the mind and its arrangement, that is, on past experience, and present intelligence. Meaning is the product of the contact between a statement and a mind, or the sum of our reactions to words. If the word 'pious' is to me a term of abuse, and to Mrs. Aimée Semple Macpherson a term of praise (or *vice versa*), it does not mean the same thing to each of us. Verbal differences give rise to differences of meaning, and the test of ability to read a language is ability to perceive fine shades of meaning. It is probable that, just as the same words mean different things to

different people, so different words may mean the same thing. We each tend to speak a language of our own, and we cannot separate words from meaning; all we can do is to guess approximately what effect we can depend on from words. When one person describes something to another, while the description may be accurate and useful, it usually fails to prevent the second person being rather surprised when he encounters what has been described to him, because the mental picture which he has made from the description by no means tallies exactly with that which was in the mind of the describer. The first person's impression requires adjustment to fit into the second's scheme of relations.

We may acquire information in two ways, directly and indirectly; directly from life and indirectly from literature, which are continually associated by contrast. Literature is often spoken of as imitating life, and when it is thought of as a contrast to life, as an ideal world, or what not, it is yet connected with life, in which it has its roots and foundation. It is difficult for words to avoid telling us something, and life is what they tell us about. Writings are not like music which makes an attack on the sense of hearing without referring to any object. A piece of writing presents to its reader life at second hand, and the experience it presents does not thereby become the reader's. If it did there would be little difference between writing a poem and reading it. The reader receives an imitation of the original experience which enables him to understand, more or less, what the original experience was like. Books have a certain resemblance to the practice of inoculation, which, as it were, produces an imitation of a disease on which the body may practise, and so may be able to recognize and deal with the real disease when it occurs. We have different attitudes towards life and literature because they are different; similarity of attitude comes from the tendency to deal with them in the same way. There is no experience which cannot be received in imitation, while there are many out of individual reach. Thus literature has a relation to life rather like that between inductive and formal logic: in the one, the mind receives an experience, but subject to external limitation; in the other, it receives an imitation only, but almost without such limitation.

To set out with full accuracy the distinctions between life and literature would be no easy task, but we can make use of a touchstone to tell them apart. We can put our finger on one distinguishing difference. The process of acquiring direct experience has directly effectual consequence; that of acquiring experience through imitation has not. In so far as the reading of books is direct experience, it has direct consequences in life; but otherwise it only

affects life indirectly, through the knowledge which is acquired from it. Many experiences actually disagreeable are enjoyable in imitation. This is because imitation is divorced from the disagreeable concomitants of the actual, and by its aid the pursuit of knowledge may go on without running counter to other innate human tendencies. It is not pleasant to lose all one's money, to become a cuckold, or to break a leg, but it is pleasant to understand what it would be like to have suffered one or all of these ills, without having to endure the actual discomfort. Like Tom Sawyer, we all wish we 'could only die temporarily.' Books are the nearest approach we can get to eating our cake and having it; and we do not get near that enviable position with the actual cake.

This does not only apply to imaginative writing, to the 'literature of power' as against the 'literature of knowledge,' in the distinction, (originally De Quincey's, which Professor Elton has adopted) but also to scientific writing. We certainly cannot, according to our definition, exclude from literature a large number of scientific works, the perusal of which unquestionably produces immediate pleasure in many people : but most of what we call scientific writing is highly specialized, and therefore, has much significance only for comparatively few people, whose minds are prepared to deal with it. But this does not mean that the pleasure they derive is of a different kind from that of other literature.

The writer who attempts to deprive words of 'additional meaning' (to coin a useful term), and to make each word signify one thing, and only one, according to the doctrine of the Royal Society (v. Sprat: *History of the Royal Society*, 1667), is doomed to fail; for the human mind is such that, no matter how the writer tries to clear his style of association and suggestion, and limit it to naked fact, the reader will find that other associations will immediately clothe the nakedness and draw increased attention to themselves by their very novelty. Precision of expression, coherent marshalling of facts, the significant presentation of new discovery, and the logical conduct of deduction and argument, in short, all the ideals of scientific style, are qualities which may produce pleasure, whether they occur in a treatise, a poem or a novel. I do not doubt that parts of, say, the works of Professor Einstein, may produce the same spinal shiver in some, as certain poetry does in others. (v. A. E. Housman—*The Name and Nature of Poetry*, 1933.) Emotional appeal is not the root of the matter, for the fact of pleasure makes emotional appeal inevitable, however the emotion may be aroused. We may distinguish various ways of causing literary pleasure, but we cannot divide the pleasure that is caused.

Herein is suggested an explanation of the pleasure we derive

from tragedy, which is not too remote from Aristotle, *viz.*, that we are enabled to undergo emotion and acquire knowledge through imitation, in a way impossible in life, because of consequences. Something similar is true of comedy, where not only does the lack of consequence enable us to laugh at what we might not be able to laugh at in life, but adds to our knowledge by enabling us to see congruities and incongruities which we might otherwise miss. Both tragedy and comedy produce pleasure by improving knowledge.

In modern existence the phenomenon of 'sport' is largely and increasingly noticeable, and golf, bridge, and detective stories go far to help the tired businessman through his leisure. Their suitability to this not wholly ignoble purpose is due to their lack of consequence. Sports and games provide experience so narrowed, arbitrarily, as to be practically incapable of serious effect, while they give opportunity for the use of bodily and mental dexterity and violence which could not otherwise be indulged without far-reaching consequences. The difference between sport and literature as means of recreation consists in the actuality of sport, which is first-hand experience with its normal disadvantages of limitation artificially increased, with a view to making it purely pleasurable, by rendering it as devoid of consequence as literature, which cannot have even the actuality of sport, but has a range incomparably greater. Literature is not play, for play implies action, which, even where it is imitative, is very close to the actual, as close as can be without fear of consequences, while such action as reading demands is without variety and has no relative connection with the kind of experience of which the imitation is received. This is not to say that reading is without consequence: but its consequences are of a different kind, which is internal, or, if external, following on internal; while those of actuality, even sport, which cannot wholly be deprived of them, are external, or, if internal, following on external. Even that internal experience, which occurs when a man thinks for himself, follows on external experience, or, if on internal, follows indirectly, after a process of transference or absorption. That is, in direct internal experience there is action in a way wanting in the indirect. In short, the difference between the first-hand experience of life, and the imitation of experience which we get from reading, is, that the first implies initial action, which has direct consequences: the second, initial reception, which has not.

J. O. B.

THE PRAKRIT DIALECT OF PRAVACANASĀRA OR JAINA ŚAURASENĪ

It is rather premature to attempt an exhaustive grammar of the gāthās of Kundakunda from his various works, because the various editions of Kundakunda's works, that we have to-day, simply represent readable individual MSS., and can hardly be called critical, as we understand that term to-day.[1] Even the present text[2] of Pravacanasāra is not strictly critical; it represents, to a great extent, the Prakrit text as preserved by Jayasena in his Sanskrit commentary; but it has, however, an advantage that it is accompanied by a table of various readings drawn from two independent MSS., one accompanied by the commentary of Amṛtacandra and the other by that of Prabhācandra. So, under the present condition of the text of Pravacanasāra, I think it better to give some of the typical and salient features of the dialect used herein than an exhaustive grammatical survey of all the works of Kundakunda or even of Pravacanasāra. It may be that some of my statements will have to be modified, when a critical text of Pravacanasāra is prepared after a faithful, unbiased and scrutinizing study of MSS. hailing from different parts of India.

The Skt. vowels, excepting *ṛ ṝ lṛ ai* and *au*, are generally in tact; a long vowel before a conjunct is shortened, the quantity remaining the same. There are, however, a few notable changes, which I give here. Of *a*: *mamatti* = *mamatva* (II. 108), *niŝĕjja* = *niṣadyā* (I. 44); of *ā*: *mĕtta* = *mātra* (II. 46, 76; III. 17, 38), Bhāsa

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1. Tradition says that Kundakunda wrote not less than 84 *pāhuḍas*; but at present only the following works are available: *Pañcāstikāya, Pravacanasāra* and *Samayasāra*; *Niyamasāra*; *Darśana-prābhṛta, Cāritra-prābhṛta, Sūtra-prābhṛta, Bodha-prābhṛta, Bhāva-prābhṛta, Mokṣa-prābhṛta, Liṅga-prābhṛta* and *Śīla-prābhṛta*; *Rayaṇasāra*; and *Dvādaśānuprekṣā*; all these works are in Prakrit verses. The first three are published in Rāyachandra Jaina Śastra-Mālā, Bombay, saṃvat 1972, 1969 and 1975 respectively, with the Skt. commentaries of Amṛtacandra and Jayasena; *Niyamasāra* is published with the Skt. commentary of Padmaprabhadeva, Bombay, saṃvat 1972; and the remaining are published in the 17th vol. of Māṇikachandra Jaina Granthamālā, Bombay, saṃvat 1976, the first six with the Skt. commentary of Śrutasāgara.

2. The text whose grammatical analysis is given below is proposed to be published in Rāyachandra Jaina Śastra Mālā, Bombay.

has the form *matta*[1]; of *ī* : *vihūṇa* = *vihīna* (III. 13; see also the v. l. I. 7, 17; II. 8); of *u* : *purisa* = *puruṣa* (III. 57), Pali also has *purisa*[2] but Bhāsa has *purusa*[3]; of *ṛ* : *gharattha* = *gṛhastha* (III. 54), *pagaḍaṃ* = *prakṛtam* (III. 61), *vasaho* = *vṛṣabhaḥ* (I. 26), *vasabha* in Pali,[4] *vitthaḍa* = *vistṛta* (I. 59); *iḍḍhī* = *ṛddhiḥ* (I. 3), *isiṇo* = *ṛṣayaḥ* (I. 33), *viddhi* = *vṛddhi* (I. 73) Pali has *vuddhi*[5] in the sense of growth, *païdī* = *prakṛtiḥ* (III. *8),[6] *puḍhavī* = *pṛthivī* (II. 40), cp. Pali *puṭhuvī*,[7] *pudhatta* = *pṛthaktva* (II. 14), *vuḍḍho* = *vṛddhaḥ* (III. 30); of *ṝ* : *kattīṇaṃ* = *kartṝṇām* (II. 68); of *e* : *dosa* = dveṣa (II. 68), cp. Pali *dosa*,[8] even in Skt. Aśvaghoṣa once has the form *pradoṣam*, which is metrically required, but the meaning is that of *pradveṣam*;[9] of *ai* : *īsariyaṃ* = *aiśvaryam*, *issariya* is a v. l., the Pali form available is *issariya*,[10] *neva* = *naiva* (I. 32), *veuvvio* = *vaikurvikaḥ* (II. 79); of *au* : *orālio* = *audārikaḥ* (II. 79), *dhovva* = *dhrauvya* (II. 8; note v. l. *dhaüvva* in P.). In this context may be noted the forms of contraction: *uggaha* = *avagraha* (I. 21), *ohi* = *avadhi* (III. 34), cp. Pali *odhi*;[11] also note *avagāha* (II. 85).

A few facts of vowel *sandhi* besides normal *savarṇa-dīrgha* and *guṇa sandhi*, may be collected here: *jiṇavariṃda* = *jinavara* + *indra* (III. 24), *maṇusiṃda* (I. 1), and *samaṇiṃda* (III. *6); *teṇiha* = *tena* + *iha* (III. 22); *dhammuvadeso* = *dharma* + *upadeśaḥ* (I. 44): *bījāṇiva* = *bījāni* + *iva* (III. 55); *tāeva* = *tāe*(*tayā*) + *eva* (III. 54). These illustrations would go to indicate that, especially in a *sandhi* of two dissimilar vowels, there is a tendency to do away with the first vowel (cp. Hema. VIII, i, 10 and also Dr. Jacobi's remarks in Samarāiccakahā, Introduction, pp. xxviii-ix). There are some cases of what Pischel calls sandhi-consonant:[12] *aṇṇamaṇṇa* (II. 81), *rāga-mādīhiṃ* = *rāgādibhiḥ* (II. 85).

The tendency of the Prakrit dialect, preserved in Pravacanasāra, is more towards the preservation of intervocalic (or as Hemacandra calls them non-initial and non-conjunct) consonants, sometimes in their original and sometimes in their softened form, than towards total elision leaving behind only the constituent vowel.

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1. Printz, *Bhāsa's Prākrit*, p. 5.
2. Geiger, *Pali Literatur und Sprache*, p. 52.
3. Printz, BP. p. 5.
4. Geiger, Pali L. Spr. p. 45.
5. Ibidem p. 45.
6. Nos. with asterisks indicate the additional gāthās in the Skt. commentary of Jayasena.
7. Geiger, Pali L. Spr., p. 45.
8. Ibidem p. 50.
9. Keith, *Sanskrit Drama*, p. 86.
10. Geiger, Pali L. Spr., p. 46.
11. Ibidem, p. 50.
12. Pischel, *Grammatik der Prakrit-Sprachen*, p. 239.

Intervocalic *k* is generally softened into *g*: *adhiga* = *adhika* (III. 66), *khāiga* = *kṣāyika* (I. 50), *guṇappagāṇi* = *guṇātmakāni* (II. 1), *pattega* = *pratyeka* (I. 3), *loga* = *loka* (I. 16), *logiga* = *laukika* (III. 53), *samagaṃ* = *samakam* (I. 3), at times it is elided making place for *ya-śruti* if possible by the nature of its position or leaving behind simply the constituent vowel: *ajjhāvaya* = *adhyāpaka* (I. 4), *ahiyaṃ* = *adhikam* (III. 70), *khāiyaṃ* = *kṣāyikam* (I. 47), *titthayara* = *tīrthakara* (I. 2), *loyāloya* = *lokāloka* (I. 23), *sayala* = *sakala* (I. 54), *sāvaya* = *śrāvaka* (III. 50); and scarcely it is retained: *adhika* (I. 19). Its presence in words like *aṃjali-karaṇaṃ* (III. 62), *baṃdha-kāraṇaṃ* (I. 76) is due to its positional advantage that it is initial of the second member of the compound. The *svārthe k* is not found in plenty as in Apabhraṃśa, and its treatment is likewise: *appagaṃ* = *ātma(-kam)* (I. 79), *maṃsugaṃ* = *śmaśru(-kam)* (III. 5), *saga-pariṇāma* = *sva(-ka)-pariṇāma* (II. 75).

Intervocalic *g* is retained: *āgama* (III. 35 etc.), *bhogehiṃ* = *bhogaiḥ* (I. 73), *roga* (III. 52), *vigada-rāgo* = *vigata-rāgaḥ* (I. 14).

The general tendency appears to be towards retaining intervocalic *c*: *ayadācāra* = *ayatācāra* (III. 17), *ālocittā* = *ālocya* (III. 12), *maṇavacikāya* = *manovākkāya* (II. 54 *3), *locāvassaya* = *locāvaśyaka* (III. 8), *vimocido* = *vimocitaḥ* (III. 2); sometimes it is dropped: *āloyaṇa* = *ālocana* (III. 12), *pavayaṇa* = *pravacana*, cp. Pali *pāvacana*,[1] while in AMg. both *pavayaṇa* and *pāvayaṇa*.

Intervocalic *j* is very often preserved: *kammarajehiṃ* = *karmarajobhiḥ* (III. 96), *tejo* = *tejas* (I. 19), *pūjāsu* (I. 69, also cp. I. *1), *bījāṇiva* = *bījānīva* (III. 55), *sahajehiṃ* = *sahajaiḥ* (I. 63); at times it is dropped: *kammarayaṃ* = *karmarajas* (II. 95), *bhoyaṇa* = *bhojana* (III. 8), *maṇuya* = *manuja* (I. 6), the form *maṇuva* = *manuja* (I. 85; III. 55) appears to be contaminated with the form *mānava*, or it may be even a case of *va-śruti* as in Pali *suva* = *śuka*.[2] In the form *pavvayido* (III. 69) *y* appears to be substituted for *j*; there is, however, a variant.

Intervocalic *ṭ* is changed to *ḍ*: *uppāḍida* = *utpāṭita* (III. 5), *koḍīṇaṃ* = *koṭīnām* (III. *19, also III. 38).

Normally and pretty often intervocalic *t* is changed to *d*: *idi* = *iti* (III. 25), *ghādi* = *ghāti* (I. 19), *cāduvvaṇṇassa* = *cāturvarṇasya* (III. 48), *jadīṇaṃ* = *yatīnām* (II. 97), *jadhajāda-rūvajādaṃ* = *yathājāta-rūpajātam* (III. 5), *devadā* = *devatā* (I. 68), *padi* = *pati* (I. 16), *mohādiehiṃ* = *mohādikaiḥ* (II. 56), even *du* = *tu* (II. 36); at times it is dropped: *aïsaya* = *atiśaya* (I. 13), *eyaṃ* = *etat* (III. 75), *ghāï* = *ghāti* (I. 1), *pariṇaï* = *pariṇati* (II. 49), *suya* = *śruta* (I. 33). With regard

1. Geiger, Pali L. Spr., p. 53.
2. Ibid, p. 55.

to the retention, change or elision of *t*, MSS. are not in agreement, as it can be very easily seen from the list of v. l. given at the end. This uncertain value of *t* upsets the p. p. forms to a great extent which are seen sometimes with *d* and sometimes with *ẏ*. From the various readings the general impression would be that Jayasena's text is perhaps under Māhārāṣṭrī influence, as at times it drops *t*, when other MSS. soften it. The present 3rd p. sg. termination, *ti*, is almost always changed to *di*, but more on this point later. Generally *t*, in the proximity of cerebral *ṛ* or *r*, perhaps through the stage of *ṭ*, is changed to *ḍ* as it were to compensate for the loss of that cerebral element in the course of transformation: *paḍivaṇṇo* = *pratipannaḥ* (II, 98), *paḍivattī* = *pratipattiḥ* (III. 46), *vitthaḍa* = *vistṛta* (I. 60, 61), *saṃvuḍo* = *saṃvṛtaḥ* (III. 40). The root *tiṣṭh* is represented by *ciṭṭh* (II. 86); MSS. AP,[1] however, would read *tiṭṭhaṃti* for *ciṭṭhaṃti*.

Intervocalic *d* is almost always preserved: *appadeso* = *apradeśaḥ* (II. 46), *ādicco* = *ādityaḥ* (I. 68), *uppādo* = *utpādaḥ* (I. 18), *uvadesa* = *upadeśa* (I. 71), *jadi* = *yadi* (III. 23), *Jiṇovadiṭṭhaṃ* = *Jinopadiṣṭam* (I. 34), *visārada* = *viśāradāḥ* (III. 63), *sadā* (I. 12); it is very scarcely that it is elided; *uvaeso* = *upadeśaḥ* (II. 84). The change of *d* to *ḍ* in *pāḍubbhavadi* (II. 11) is due to cerebral proximity as remarked above in the case of *t*; the other MSS., however, do not preserve this reading. In this context may be noted *orālio* = *audārikaḥ* (II. 79).

There is only cerebral nasal in the dialect of Pravacanasāra; thus *n* initial, medial or conjunct is changed to *ṇ* without exception: *jiṇakkhāde* = *jinākhyātān* (III. 64), *ṇivvāṇa* = *nirvāṇa* (I. 6), *ṇevaṇṇoṇṇesu* = *naivānyonyeṣu* (I. 28), *maṇuvo* = *manujaḥ* (II. 21).

Intervocalic *p* is changed to *v*: *aṇovama* = *anupama* (I. 13), *ṇiravekkho* = *nirapekṣaḥ* (III. 26); scarcely it is retained even; *ghoramapāraṃ* (I. 77).

Intervocalic *kh* is changed to *h*: *suha* = *sukha* (I. 13, 14), *suhidā* = *sukhitāḥ* (I. 73); it is initial by its position in *kāya-khedaṃ* (III. 50). Intervocalic *th* is at times softened into *dh* and at times changed to *h*: *kadhaṃ* = *katham* (II. 14), *jadhā* = *yathā* (II. 82; III. 30), *pudhattaṃ* = *pṛthaktvaṃ* (II. 14); *jahā* = *yathā* (I. 30), *maṇorahā* = *manorathāḥ* (I. *9). *th* is changed to *ḍh* in *puḍhavī* (II. 40), which is due to cerebral proximity. The normal tendency is towards preserving intervocalic *dh*: *aṇegavidhaṃ* = *anekavidham* (II. 32), *adhiga* = *adhika* (I. *4), *cakkadhara* = *cakradhara* (I. 73), *padhāṇa* = *pradhāna* (III. 49, 61), *madhumaṃsaṃ* = *madhumāṃsam* (III. 29),

1. A = a MS. with the Skt. commentary of Amrtacandra and P = a MS. with Prabhācandra's commentary; both of them from the Ailaka Pannālāl Sarasvatī Bhavana, Bombay.

vidhāṇa = *vidhāna* (I. 82); at times it is changed to *h*: *ahiyaṃ* = *adhikam* (III. 70, MSS. AP differ), *pahāṇa* = *pradhāna* (I. 6, 18*1; here also MSS. vary), *vivihāṇi* = *vividhāni* (I. 74), *sāhū* = *sādhuḥ* (III. 52, MSS. vary). From the various readings, it would be clear that Jayasena's text, at times, has an inclination towards *h*. Intervocalic *bh* is generally changed to *h* : *lahadi* = *labhate* (II. 29), *vasaho* = *vṛṣabhaḥ* (I. 26, III. 1); *vibava* = *vibhava* (I. 6), *sahāva* = *svabhāva* (II. 24, 91), *suheṇa* = *śubhena* (I. 9, III. 46); at times it is retained: *aṇubhāgo* = *anubhāgaḥ* (II. 95*4), *abhibhūya* (I. 29), *ṇabho* = *nabhas* (II. 44), *sabhāva* = *svabhāva* (II. 92).

Generally initial (of a word even in a compound) *y* is changed to *j*: Jadā = *yadā* (I. 10), *jadi* = *yadi* (I. 9), *judo* = *yutaḥ* (II. 95); *abhijutta* = *abhiyukta* (III. 46); *uvajutta* = *upayukta* (III.* 17); at times non-initial *y* is retained: *adiṃdiyattaṃ* = *atīndriyatvam* (I. 20), *samavāyo* = *samavāyaḥ* (I. 17); *saṃpayogajudo* = *saṃprayogayutaḥ* (I. 11); at times it is dropped: *uvajogamao* = *upayogamayaḥ* (II. 35), *suddhovaoga* = *śuddhopayoga* (I. 13).

Generally *r* is retained: *agārī* (III. 50), *aṇaṃtavaravīrio* = *anantavaravīryaḥ* (I. 19), *devāsura* (I. 6), *pariṇāmo* = *pariṇāmaḥ* (II. 88); it is very scarcely that *r*, initial as well as non-initial, is changed to *l*: *lukkha* = *rūkṣa* (II. 73–4) cp. Pali *lukha*,[1] AMg. *lukkha* also *lūha*, *orālio* = *audārikaḥ* (II. 79) Cp. Pali *uḷāra* = *udāra*,[2] our form is perhaps a further metathesis. Because *r* has a strong cerebral element in its pronunciation and because *t*, on account of cerebral proximity, is changed to *ḍ*, we find that *paḍi* is indiscriminately equated with *pari* as well as *prati*; and hence *paḍipuṇṇasāmaṇṇo* = *paripūrṇa-śrāmaṇyaḥ* (III. 14).

Intervocalic *v* is preserved: *viviho* = *vividhaḥ* (I. 84), *sahāva* = *svabhāva* (II. 24), *sāvaya* = *śravaka* (III. 50). Note *jiyadu* = *jīvatu* (III. 17, MSS. AP read *jīvadu*).

Of the sibilants only the dental, *s*, is allowed: *kusalo* = *kuśalaḥ* (I. 92), *daṃsaṇa* = *darśana* (I.*7), *padesa* = *pradeśa* (II. 46), *pesīsu* = *peśiṣu* (III.* 18), *visaya* = *viṣaya* (II. 66), *sayaṇa* = *śayana* (III. 16).

It is necessary to note, at this stage, the position of *ya-śruti*[3] in this dialect of Pravacanasāra. *Ya-śruti* is recognised under certain circumstances. If a consonant Is dropped leaving behind a vowel, *ya-śruti* occupies that vowel provided that vowel is *a* or *ā*: *āloyaṇa* = *ālocana* (III. 11), *odaïyā* = *audayikāḥ* (I. 45), *kammara-*

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1. Geiger, Pali L. Spr., p. 59.
2. Ibid. p. 59.
3. Pischel, Gr. Pr. Spr., p. 157; M. Ghosh, Prākrta Verses in the *Bhārata-Nāṭyaśāstra*, p. 8, in IHQ. vol. VIII. 4; Dr. Vaidya, *A Manual of AMg. Grammar*, Poona, 1933, pp. 19–20.

ẏaṃ = *karmarajas* (II. 95), *loẏâloẏa* = *lokâloka* (I. 23); *sāvaẏa* = *śrāvaka* (III. 50); this *ẏa-śruti* does not develop in case the remaining vowel to be occupied is not *a* or *ā*: *aïsaya* = *atiśaya* (I. 13), *uvaeso* = *upadeśaḥ* (II. 84), *davvâdiesu* = *dravyâdikeṣu* (I. 83); but *y*, to be distinguished from *ẏ*, can be coupled, under such circumstances, with any vowel, if the consonant to be dropped in the Skt. word is *y* itself: *iṃdiyehi* = *indriyaiḥ* (I. 63), *palayida* = *pralayita* (I. 39), *visaye*=*viṣayān* (II. 83): *visayesu*=*viṣayeṣu* (III. 73). In this context I may be allowed to have a digression: *Ẏa-śruti* appears to be *originally* a peculiarity of Jaina Prakrit dialects (see Caṇḍa: Prākṛta lakṣaṇa, III, 39; Hema: VIII, i, 180). Hemacandra, whose rule is clearer than that of Caṇḍa, makes its scope very limited. For the development of *ẏa-śruti*, he says, (1) the constituent vowel should be *a* or *ā* and (2) the preceding vowel also should be *a* or *ā*, i. e., in other words, *ẏa-śruti* can develop between *a-varṇas* (*avarṇa* meaning *a* and *ā*); he admits, however, by the illustration *piẏaï* = *pibati*, that the second condition is at times violated. A scrutiny of pre-Hemacandra literature, whether in Ardha-Māgadhī, Jaina Śaurasenī or Jaina Māhārāṣṭrī, will show that his second condition is more violated than observed; and to fulfil the phonetic needs the first condition is quite sufficient. The position of *ẏa-śruti* in Pravacanasāra as enunciated above, though not in complete agreement with Hemacandra's rule, almost wholly agrees with the usage of the Ardha-Māgadhī canon; it is only some modern editors that try to follow Hemacandra literally. Even in Pali, *ẏ* at times develops in the place of a consonant dropped: *khāẏita* = *khādita*, *niẏa* = *nija*,[1] etc.

Just to have a glimpse of the treatment of conjunct consonants, initial as well medial, some typical cases from Pravacanasāra are put together here: *itthī*=*strī* (I. 44), *gilāṇa*=*glāna* (III. 30) *gilāna* in Pali, *cāga*=*tyāga* (III. 20), *chudhā* = *kṣudhā* (III. 52) *khudhā* in Pali,[2] *ṇāṇam*=*jñānam* (I. 19), *ṇiddhā*=*snigdhā* (II. 71) Bhāsa has *siṇiddha*,[3] *thāvara*=*sthāvara* (II. 90), *phāso* (v. l. *paraso*) =*sparśaḥ* (I. 56) Bhāsa has *parisa*,[4] *maṃsuga*=*śmaśru* (-*ka*). Then some cases of assimilated, non-initial conjuncts may be noted: *ajjhattha*=*adhyātma* (?) (III. 73), *aṭṭha* and *attha*=*artha* (I, 10, 18, 26, etc.), *appā*=*ātmā* (I. 7, II. 33), *ādā*=*ātmā* (I. 8, II. 33), *ussāsa* = *ucchvāsa* (III. 38). This form—*ussāsa*[5] is in the mouth of Vidūṣaka in the fragments of Aśvaghoṣa's dramas and Dr. Lüders calls it a form of Old Śaurasenī. *chaḍḍiyā*=*charditā* (III. 19), the

1. Geiger, Pali L. Spr., p. 55.
2. Ibidem p. 67.
3. Printz, BP. p. 12.
4. Ibidem p. 12.
5. Lüders, *Bruchstücke Buddhistischer Dramen*, p. 45.

form *vicchaḍḍaṃ* [1] occurs in the fragments of Aśvaghoṣa's dramas, and it is regarded as a Śaurasenī feature; *taccaṃ=tattvaṃ* (II. 16); *taccaṇhū=tattvajñaḥ* (II. 105), *daṃsaṇa=darśana* (II. 100), *dhŏvva* (v. l. *dhaüvva*)=*dhrauvya* (II. 8), *pakkhīṇa=prakṣīṇa* (I. 19), *pajjaya* and *pajjāya=paryāya* (I. 10, II. 1), *pŏggala* or *puggala*=*pudgala* (I. 34, II. 40; II. 76), *puvva=pūrva* (II. 47) Pali *pubba*. Bhāsa has *puruva*, [2] and Hema. requires *purava* in Śaurasenī, *māhappaṃ=māhātmyam* (I. 57), *vacchaladā=vatsalatā* (III. 46), *Vaḍḍhamāṇa=Vardhamāna* (I. 1), *savvaṇhū=sarvajñaḥ* (I. 16), *saṃṭhāṇa=saṃsthāna* (II. 60). The simplification of a conjunct is, at times, achieved by anaptyxis: *arahaṃta=arhan* (I. 3), *ariho* = *arhan* (I.*3), *kiriyā=kriyā* (I. 27, II. 24), *chadumattha=chadmastha* (III. 56), *daviya=dravya* (II. 62), *pariyaṃta = paryanta* (II. 40), *rayaṇa=ratna* (I. 39) another reading is *radaṇa*. Bhāsa has both these forms; [3] *vīriya=vīrya* (I. 1), *suhuma=sūkṣma* (II. 45, 75; III.*2,*12; once *suhama* III.*11).

To have some idea of the morphological scheme of the dialect of Pravacanasāra, some typical forms are noted here; Masculine nouns, Singular: Nom. *dhammo* (I 7); Acc. *uvadesaṃ* (I. 88); Inst. *kāleṇa* (III. 75), *guruṇā* (III. 7); Dat. *ṇiggamatthāe* (?) (III. 17*1); Abl. *carittādo* (I. 6, see II. 37); Gen. *bhavassa*, (II. 92); Loc. *loge* (I. 68); *dāṇammi* (I. 69), *cariyamhi* (I. 79). In Pali we have *dhamme, dhammassiṃ* and *dhammamhi*,[4] and the Girnar edict of Aśoka has Loc. sg. in *-amhi*.[5] Plural: Nom. *samayā* (III. 1), *isiṇo* (I. 33); Acc. *titthayare* (I. 1), *mohādī* (I. 79): Inst. *vihavehiṃ* (I. 6), *ŏggahâdihiṃ* (I. 59), and sometimes without *anusvāra*; Gen. *surāṇaṃ* (I. 71), *sāhūṇaṃ* (I. 4); Loc. *suhesu* (I. 62). Neuter nouns, Singular: *davvaṃ* (I. 8); Acc. *jagaṃ* (I. 29); Loc. *jagadi* (I. 26); Plural: *rūvāṇi* (I. 28), *liṃgāṇi* (I. 85). Some typical forms of feminine nouns may be noted: Nom. sg. *devadā* (I. 68), *saṃpattī* (I. 5); Acc. sg. *taṇhaṃ* (I. 74); Inst. *aṇukaṃpayā* (III. 57), *chudhāe* (III. 52), *niyadiṇā* (I. 43), *bhāsāe* (I. 30), *saṇṇayā* (I. 87); Inst. pl. *taṇhāhiṃ* (I. 75); Abl. sg. *uvadhīdo* (III. 19); Gen. sg. *itthissa* (III. 13); Gen. pl. *itthīṇaṃ* (I. 44); Loc. sg. *uvadhimhi* (III. 15), *cĕṭṭhamhi* (III. 19), *vikadhammi* (III. 15). Some typical forms of consonantal stems may be noted: Nom. sg. *ādā* (I. 66), *ṇāṇī* (I. 28), *bhagavaṃ* (I. 32); Acc sg. *appāṇaṃ* (I. 33), *kevaliṃ* (I. 33), *ādaṃ* (I. 33); Inst. sg. *jammaṇā* (III.*7); Gen. sg., *appaṇo* (I. 81), *dehissā* (I. 66). Of the

1. Ibidem p. 47.
2. Printz. BP. pp. 5 and 13.
3. Ibid. p. 12.
4. Geiger, Pali L. Spr., p. 79.
5. Woolner, *Asoka Text and Glossary*, part I, p. xxi.

pronominal forms a few typical ones may be noted : Nom. sg. *esa* (I. 1), *jo* (I. 7), *so* (I. 7) ; Acc. pl. *ede* (I. 91), *te, savve* (I. 3); Abl. sg. *jamhā* (I. 20) ; *tamha* (I. 84), *jatto* (I. 5), *tatto* (II. 29), Abl. pl. *tehiṃdo* (II. 90) ; Gen. pl. *tesiṃ, savvesiṃ* (I. 4,5), fem. *tāsiṃ* (III. 24*10).

Coming to the conjugational forms, we have : Present 1st p. sg. *paṇamāmi* (I. 1), *vaṃdāmi* (I. 3), *maṇṇe* (II. 100) ; 3rd p. sg. *havadi* (I. 65), *hodi* (I. 18), *pajahadi* (II. 20), *passadi* (I. 29), *pĕcchadi* (I. 32), *pāvadi* (I. 88), *pappodi* (III. 75) cp. Pali *pāpuṇāti*; *jāyadi* (II. 27), *gĕṇhadi* (I. 31), *atthi* (I. 53) ; *karedi* (I.*2), *kīradi* (II. 92), *kuṇadi* (I. 89, II. 57, III. 50) ; *dhāredi* (II. 58), *bibhedi* (III.*5) ; *jādi* (I. 15), *jhādi* (II. 59), *ṇādi* (I. 25) ; 3rd p. pl. *khīyaṃti* (I. 19,*1), *parūvĕṃti* (I. 39), *vaṭṭaṃti* (III. 67), *vaṭṭaṃte* (I. 37), *hŏṃti* (I. 38). The 3rd p. sg. termination, as seen from the above illustrations, is necessarily *di*; it is only in three or four places Jayasena's text read *i*, but, being backed by other MSS., I have corrected it to *di*. In gāthā No. III. 20*5, Jayasena has *i* throughout; I have not changed it, as I had not the advantage of collating other MSS. of Jayasena's text; but it is seen from the variants, that P has *di* throughout. Future 3rd p. sg. *bhavissadi* (II. 20). Imperative : 2nd p. sg. *jāṇa* (II. 79,87), *jāṇīhi* (II. 82), *viyāṇa* (I. 64) ; 3rd p. sg. *abhigacchadu* (I. 90), *paḍivajjadu* (III. 1), *maradu* (III. 17). The potential or the optative 3rd p. sg. of the root *as* is preserved as *se*=*syāt* (III. 49, 50), which is peculiar to our text; in AMg. it is *siyā*, but a prototype of *se* can be suspected in forms like *haṇe* etc.[1] in Acārāṅga of the Śvetāmbara canon; cp. Pali *labhe*[2] for optative 3rd p. sg.

Some typical present participles are: *ahŏjjamāṇo*=*abhavan* (II. 21), *uvadisadā*=*upadiśatā* (II. 5), *jahaṃ*=*jahat* (II. 20), *pariṇamado*=*pariṇamamānasya* (I. 21), *pariṇamamāṇa*=*pariṇamamāna* (II. 26), *bhavam*=*bhavan* (II. 14,20), *vaṭṭaṃte*=*vartamānān* (I. 3), *hŏjjaṃ*=*bhavaṃ* (II. 103). Generally, the past passive participle forms are the corruptions of the Skt. forms; the uncertainty about the retention or otherwise of intervocalic *d* upsets these forms to a great extent; some typical forms are noted here: *apariccatta*=*aparityakta* (II. 3), *udiṇṇa*=*udīrṇa* (I. 75), *gada* and *gaya*=*gata* (I. 50,31), *jutta*=*yukta* (I. 70), *ṇivvāda* =*nirvāta* (I. 82), *dhoda*=*dhauta* (I. 1), *bhaṇida* and *bhaṇiya* (II. 32, I. 34), *samāraddha*=*samārabdha* (II. 32), *saṃchaṇṇa*=*saṃchanna* (I. 77), *siliṭṭha*=*śliṣṭa* (II. 96). Some of the typical gerund forms are : *kiccā*=*kṛtvā* (I. 4,82), *paducca*=*pratītya* (I. 50, II. 40); *khittā*=*kṣiptvā* (III. *5), *cattā*=*tyaktva* (I. 78, II. 98), *dattā*=*datvā* (III. *20),

1. Schubring, *Ācārāṅga-sūtra*, p. 12 etc.
2. Geiger, Pali L. Spr. p. 110.

diṭṭhā = *dṛṣṭvā* (III. 52, 61, 68, I. *8) compare *puṭṭhā*[1] in Ācārāṅga for *pṛṣṭvā*; *āpiccha* = *āpṛcchya* (III. 2), *āsējja* = *āsādya* (I. 5, II. 92, also read *āsijja* III. 2); *abhibhūya* (I. 30, II. 25), *uvalabbha* = *upalabhya* (I. 88), *paṇamiya* = *praṇamya* (III. 2), *pappā* = *prāpya* (I. 65 etc. II. 77–8); *jāṇittā* = *jñātvā* (II. 102), *ṇamaṃsittā* = *namaskṛtya* (III. 7), *nirumbhittā* = *nirudhya* (II. 104); *suṇidūṇī* = *śrutvā* (I. 62), *bhavīya* = *bhūtvā* (I. 12, II. 20), *khavīya* = *kṣapayitvā* (II. 103). Some typical forms of the Infinitive of purpose are: *deduṃ* = *dātum* (II. 48), *ṇāduṃ* = *jñātum* (I. 40, 48) *bhŏttuṃ* = *bhoktum* (III. *20). From the following forms, when studied in their context, it appears that the past passive participles are made to serve the purpose of the past active participles: *uddiṭṭhā* = *uddiṣṭavantaḥ* (III. 24), *kammamevuttā* = *karmaivoktavantaḥ* (I. 42), *samakkhādā* = *samākhyātavantaḥ* (II. 6). The typical forms of the potential passive participle or necessitative are: *abbhuṭṭheya* = *abhyuttheya* (III. 63), *kāyavva* = *kartavya* (I. 67, III. 12), *ṇeya* = *jñeya* (I. 20), *paṇivadaṇīya* = *praṇipataniya* (III. 63), *muṇedavvo* = *jñātavyaḥ* (I. 8, II. 2, 39), *samadhidavva* = *samadhyetavya* (I. 86), *saṃkhavaïdavva* = *saṃkṣapayitavya* (I. 84). Particles: *a* (I. 85), *ya* (I. 3); *jahā* (I. 30), *jadhā* (II. 82, III. 30), *jadha* (II. 45); *taha* (I. 4), *tahā* (II. 65), *tadha* (II. 6, III. 21); *puṇa* (I. 1), *puṇo* (I. 17); *khalu* (I. 6), *khu* (II. 10); *iti* (II. 5, 6), *idi* (II. 99, III. 4, 36), *ti* (after an *anusvāra*) (I. 36), *tti* (I. 8); with regard to the use of *tti*, following illustrations may be noted in which *tti* appears to do away with the preceding termination: *tammaya tti* (I. 8), *parŏkkha tti* (I. 58), *davva tti* (I. 87), *saṃga tti* (III. 24); *du* (I. 18, II. 30), *vi* (I. 18), *pi* (after an *anusvāra*) (III. 3); *hi* (II. 24); *va* (I. 27), *vā* (I. 20); *kahaṃ* (I. 24), *kadhaṃ* (I. 57, II. 21, III. 21), *kiha* (II. 59, III. 58), *kidha* (I. 49, III. 21); *va* (III. 18), *vva* (I. 44), *tāvadi* (I. 70), *cciya* (III. 74); *jadi* (III. 68); *kila* (III. 29, *19).

Some of the numerals are: *ega* (I. 48), *ĕkka* (II. 10, 49); *duga* (II. 49), *cadu* (II. 55). A few typical words, which have not been illustrated heretofore, can be noted here: *jāṇaṇā* = *jñaptiḥ* (I. 134), *jidiṃdo*=*jitendriyaḥ* (III. 4), *jugavaṃ*=*yugapat* (I, 47), *jŏṇhaṃ*=*jainam* (I. 51, 88, III. 6, once the reading is *jĕṇhaṃ*), *duguṃchā*=*jugupsā* (III. 24*9) cp. Pali. *jigucchā*.

With this grammatical survey it is possible to define the position of the dialect of Pravacanasāra in the scheme of Prakrit dialects. This dialect, in fact, has many features common to Prakrits, as a whole, such as the loss of vowels *ṛ* and *lṛ* and of the dipthongs *ai* and *au*; general tendency towards changing the intervocalic consonants; reduction of the three sibilants to one; the reduction of the nasals; and the tendency to assimilate the

1. *Ācārāṅga-sūtra*, ed. Schubring, p. 34.

conjunct when it is not simplified by anaptyxis. Words like *mĕtta, vihūṇa, vuḍḍha* etc. may be found in almost all dialects. With respect to vowel changes and the consequent forms of words like *iḍḍhi, isī, orāliya, ohi, dosa, nisĕjjā, pagaḍa, vasaho* (*°bho* in AMg.), *veuvvio, saṃvuḍo* etc., they are a common property with AMg. of the Śvetāmbara canon; some of them are found in Jaina Māhārāṣṭrī of the Śvetāmbara post-canonical literature, only because JM. inherits many features of AMg. Forms like *pagada, pudhatta* etc. smeck of Śaurasenī.

The treatment accorded to intervocalic consonants, especially stops, is of a very uncertain character; the general tendency is towards softening or retention, a phenomenon quite usual in the early texts of the AMg. canon and in Śaurasenī; in Bhāsa's Śaurasenī retention or softening of intervocalic consonants is still facultative, while in that of Kālidāsa the tendency is towards omission. It must be remembered that the Śvetāmbara canon has been, in later days, subjected to a strong Māhārāṣṭrī influence, because, since the days of Vallabhi redaction, 980 years after Mahāvīra, the canon came to be shaped, nourished, nurtured, copied and studied, in western India, especially in Gujarat and Kathiawar. Still words like *aṇega, udahī, logâloge, vibhāga* etc. can be seen on any page of the canonical texts, and they indicate the non-Māhārāṣṭrī element of AMg. The softening of *k* to *g* is merely an extension of the Śaurasenī phenomenon, generalised by grammarians, of softening *t* and *th* to *d* and *dh*. The retention of *g* is quite normal in AMg. of the canon. The retention of *c* and *j* exhibit a strong contrast with normal Māhārāṣṭrī. The softening of *t*, which is almost universally taken recourse to in Pravacanasāra is peculiarly Śauraseni and extended by grammarians to Māgadhī and other dialects; as a result of this the Present 3rd p. sg. termination is necessarily *di*, which, according to critical editors, is *i* in AMg. texts, though some editors of the orthodox school would preserve *ti*. The treatment accorded to dental nasal in Pravacanasāra is worthy of note: it is universally cerebralised whether initial, medial or conjunct; and this is in agreement with Śauraseni. Turning to Prakrit grammarians on this point, Vararuci wants unexceptional cerebralisation, while Hemacandra says that dental may be retained if initial. Coming to the practice in AMg., the MSS. are never in agreement; but critical scholars, from Weber to Vaidya,[1] have created a substantial convention of retaining a dental at the beginning of a word and of changing it to cerebral elsewhere. Exception is, however, made in the case of *ṇaṃ* (Leumann

1. Weber, Über ein Fragment der *Bhagavatī*, Berlin, 1866-67; Dr. Vaidya—his editions of *Nirayāvaliyāo, Aṃtagaḍadasāo* etc. and *Vivāgasuya* etc., Poona,

retains forms like *ṇūṇam, ṇo* etc. See Das Aupapātika sūtra, sections 132–3, 137 etc.).[1] With regard to conjunct *nn* or *ṇṇ* Dr. Jacobi's rule[2] *ṇṇ* should be preferred, if there is *ṇ* in the Skt. original, otherwise *nn*; but one must say that Dr. Jacobi has over-extended his convention, when he prints *savvannū*, which, as a matter of phonetic necessity, should be *savvaṇṇū* (Cp. Hemacandra, VIII, i. 56; ii. 83). Our MSS. of Pravacanasāra are almost in agreement in preferring *ṇ* everywhere, and that has been uniformly followed. The treatment of aspirated consonants like *th, dh, bh* at times agrees with AMg. and at times with Śaurasenī. The phenomenon of *ya-śruti* is practically the same as in AMg. canon, though in JM., as seen in modern editions, there is a tendency to observe strictly the rule as framed by Hemacandra. In AMg. there are many cases where *r* is changed to *l*; but in our text the tendency is towards retaining *r*, though we have a few cases of *r* changing to *l*; this is more in agreement with Śaurasenī.

Coming to the treatment of conjunct consonants, typical words like *ādā (āyā* in AMg.), *gilāṇa, ṇiddha, thāvara, suhuma*, etc., are quite usual in AMg. canon. In Pravacanasāra we get *puvva*, which, according to Hemacandra, is optionally *purava* in Śaurasenī.

In morphology the Nom. sg. termination of *a-* stems is *o*, which agrees with Śaurasenī and partially with AMg. The Loc. sg. has *e,-ammi* or *-aṃmi* and *-amhi* or *-aṃhi. e* and *-ammi* are normal in AMg. It is a point *sub judice*, whether *-ammi* is possible in Śaursaenī; it is not forbidden by Hemacandra; it is only later grammarians like Mārkaṇḍeya that have not allowed it in Śaurasenī. With no discredit to the worth of Prakrit grammarians, I might say that it is an innocent anachronism that Mārkaṇḍeya should be a judge on the Prakrit of a writer like Rājaśekhara, though eminent Prakritists like Konow have adopted this view. If usage (evidenced by good MSS.) and phonetic possibility are taken into consideration, *-ammi* is not impossible in Śaurasenī. Our text has *-amhi* in addition; it is also spelt as *-aṃhi*: it is found in the Girnar edict of Aśoka as already noted above. The Loc. sg. of *jagat* as *jagadi* only betrays strong Skt. influence. The instrumental sg. termination for fem. nouns ending in *ā* is *e*, which is quite normal, but at times the Skt. form is retained as in *aṇukampayā*. The Loc. sg. forms are worthy of note, as some fem. nouns with *ā-* stems are treated as masculine nouns in *a-* stems: *vikadhammi* from *vikathā, ceṭṭhammi* from *ceṣṭā* etc.; the Gen. sg. of *strī* is *itthissa*; these forms of feminine nouns are, so far as I know, the peculiarities of our text alone. Coming to the pronominal forms, the Abl. pl. of *tad* is *tehiṃdo*, which is Śaurasenī with vengeance.

1. Dr. Vaidya, *A Manual of AMg Grammar*, pp. 21-22.
2. Dr. Jacobi: *Āyāraṃga sutta*, PTS. London, 1882, p. xv.

The present 3rd p. sg. termination is decidedly Śaurasenī. The future 3rd p. sg. form *bhavissadi* is not Śaurasenī according to Hemacandra's standard. The forms of the gerund and infinitive of purpose agree either with AMg. or Śaurasenī ; if not, they are the corruptions of Skt. forms, directly or through false analogy, according to recognised rules of phonetic corruption.

Besides this vacillation between AMg. and Śaurasenī, there is another strong influence working on the Pkt. dialect of Pravacanasāra : and that is of Sanskrit. We come across forms like *jāṇaṇṇavi*, *taṇṇa*, *tavvivarīdo* etc., which indicate that the author has in his mind the Skt. idiom quite predominantly. This explains also the tendency to retain intervocalic *c* at times and even *p* in phrases like *ghoramapāram*. Even the ready-made Skt. forms are subjected to phonetic corruption and imported, for instance *jagadi*, *divā* (*diyā* in AMg,), ṇādā (I. 42), *saṇṇaya*, which are very scarce elsewhere. The past p. participles and the gerund forms show that they are corrupted from Skt. Some roots necessarily retain their Ātmanepada colour. The verbal forms like *jaṇayaṃti*, *pappodi* and *bibhedi* substantiate the same conclusion.

Thus this dialect of Pravacanasāra, in short, inherits many features of AMg. dialect of the Śvetāmbara canon ; it is nourished in the back-ground of Śaurasenī ; and thereon a strong influence of Sanskrit is working.

Then what significant name can be given to this dialect of Pravacanasāra ? Pischel,[1] with the analysis of a few gāthās from Pravacanasāra and Kattigeyâṇuppĕkkhā as quoted by Bhandarkar,[2] came to the conclusion, with a remarkable grasp and suggestiveness, that this dialect should be called Jaina Śaurasenī. This christening was quite in agreement with the precedent that the dialect of the post-canonical literature of the Śvetāmbaras, which represented an admixture of Ardha-Māgadhī and Māhārāṣṭrī, was called Jaina Māhārāṣṭrī by Dr. Jacobi. But some German scholars have questioned the accuracy of the designation, Jaina Śaurasenī. In his lecture,[3] delivered at Delhi, in 1928, Dr. Walther Schubring passingly refers to the fact that the Digambara works like Mūlācāra etc. are interesting for the grammatical exposition as shown by one of his pupils, who was connected with an investigation in Mūlācāra and other important Digambara treatises ; and in conclusion he remarks : 'The future will teach us whether the signification Pischel proposed, viz., Jaina Śaurasenī, will appear adequate.' It appears that Dr. Schubring is sceptic on that point. I am not aware of the

1. Pischel, Gr. Pr. Spr., p. 20.
2. *Report on Search for Sanskrit MSS.*, 1883-84.
3. Published in *Vira*, a Hindi monthly, vol. V, pp. 11-12.

publication of any essay on Vaṭṭakera's Mūlācāra; and hence I am not in a position to know the conclusions arrived at by the pupil of Dr. Schubring. Then W. Denecke, in his 'Observations on the Digambara texts', published as an essay in Festgabe Jacobi, discusses various points about some Digambara Pkt. works, such as Mūlācāra of Vaṭṭakera, Kattigeyâṇuppĕkkhā of Kumāra, and Chappāhuḍa, Samayasāra and Pañcâstikāya of Kundakunda; it is only on the language of these works that W. Denecke concentrates his attention; and most of his illustrative forms have been drawn from Chappāhuḍa. On the whole, the dialectal facts arrived at by Denecke are practically the same as those noted by me above in connection with Pravacanasāra except in one respect. He remarks that the language of these works is influenced 'by Ardhamāgadhī, Jaina Māhārāṣṭrī which approaches it and Śaurasenī'; from some of the illustrations given by himself, he would not hesitate to accept the influence of Skt. The only one aspect, where our facts are not in agreement, is that he finds some Apabhraṃśa forms in Chappāhuḍa and Kattigeyâṇuppĕkkhā; as he has not given any Apabh. forms from Pravacanasāra, my conclusions remain unaffected. The majority of Apabh. forms, which Denecke notes, are from Chappāhuḍa; and the reasons why in Chappāhuḍa alone so many Apabh. forms are found are these: the Pāhuḍas are easy and hence very often studied; in early days even the commentaries were not needed; the only commentary that appears to have been written and is available is that of Śrutasāgara, who lived about the beginning of the 16th century A. D.[1]; so the texts of Pāhuḍas have suffered dialectal changes here and there in the course of oral transmission and study, and the Apabh. forms are there, because the Digambaras were cultivating Apabhraṃśa side by side with other languages, either traditionally inherited or adopted from different places, wherever they went.

In the light of the dialectal facts considered by him, Denecke says that it was unlucky that Pischel called this dialect as Jaina Śaurasenī; that Pischel's treatment and conclusion are not free from mistakes; and that according to his opinion, the name 'Digambari language' is a better designation. I do not understand, when there is practical agreement between Pischel and himself, and between his results and those of mine (excepting Apabh. elements in Chappāhuḍa), why Denecke objects to the designation, Jaina Śaurasenī. Any name can be given, just as Jacobi once intended to call Jaina Māhārāṣṭrī as Jaina Saurāṣṭrī[2]; but one must prove first that the name previously suggested is connotatively defective, and that the name proposed

1. *Annals* of the B. O. R. I., XII, ii, p. 157.
2. His Introduction to *Kalpasūtra*, Leipzig, 1879.

is more significant. As remarked above, Pischel's designation has been not without a precedent; the name, Jaina Śaurasenī, is capable of signifying the main traits of the Śaurasenī dialect. The word Jaina shows that it is primarily handled by Jaina authors, that it contains some dialectal features of Ardha-Māgadhī, the traditional name of the canonical language of the Jainas; the word Śaurasenī shows that it has some parallels with Śaurasenī of the grammarians and even of the dramas; and further the term Śaurasenī is wide enough to imply the Sanskritic influence, as the Śaurasenī of Skt. dramas is moulded after the fashion of the Skt. idiom. So Pischel's designation is sufficiently significant, and no new christening is needed. The new name proposed by Denecke is not significant and comprehensive. The name, Digambari language, on the very face of it, does not indicate a Pkt. dialect; it ignores the deep Śaurasenī background of the dialect; and it is misleading, in view of the fact that the Digambara authors have adopted, at different periods as well as side by side, different languages and dialects as the one we are discussing, Sanskrit, Tamiḷa, Kannaḍa, and so forth. Thus Denecke's proposed designation is not significant, as it includes matter not needed and excludes important traits of the dialect. I am aware that this Jaina Śaurasenī, the dialect of the gāthās of Pravacanasāra, has come, in later days, under the influence of Māhārāṣṭrī and Apabhraṃśa, but that is outside the scope of the present discussion. To conclude, Pischel's designation viz., Jaina Śaurasenī, is sufficiently significant, and it need not be changed, simply for the sake of changing it.

Is it possible to outline the historical background and the circumstances, that might have been responsible for the shaping of the Jaina Śaurasenī dialect? A couple of centuries after the *nirvāṇa* of Mahāvīra, as a result of the severe famine that is said to have taken place in Magadha, a portion of the Jaina community, under the leadership of Bhadrabāhu, migrated to the South;[1] and this has been the historical starting point of Jainism in South India. The Jainas, that migrated to the South, could conveniently stick up to their ascetic practices; but those, that remained behind, became slack, to a great extent, due to difficult days of famine. At the end of the famine, the members of the ascetic community in the North convened a *saṅgha* for the restoration of the sacred canon, as, so many monks, who were the repositories of the sacred lore, had been the victims of famine. It was at Pāṭaliputra that the canon was shaped, as it was then available from the various monks that had survived the famine. This canon, naturally, being shaped wholly by those that were remaining in the North and who had

1. *South Indian Jainism*, Chapter II; *Ardhamāgadhi Reader*, ixl, etc.

apparently slackened their ascetic practices, was not acceptable to those that had migrated to the South. Here is the visible seed of the division of the Jaina church under the denominations of Śvetāmbara and Digambara, as they came to be known later on. It was a practical step, on the part of the Śvetāmbaras, that they tried to restore the sacred texts as much as it was possible under the then prevailing circumstances; and it is this canon, after passing through various vicissitudes, that was committed to writing, almost as it is to-day, under Devarddhigaṇi, at Valabhi, in the year 980 after the *nirvāṇa* of Mahāvīra. The Digambaras, in their zeal for the genuine canon, did neither restore it themselves, nor could they accept the canon as shaped by the Pāṭaliputra *saṅgha*, with the result that the community, as a whole, came to lose the sacred canon. But, when we take into consideration the ancient method of study, that the teachers and pupils relied more on their memories than on the material accessories of knowledge like MSS. etc., it is imaginable that the leading teachers among the Digambaras, in the South, might have utilised, on such an occasion, the knowledge of what they had studied from their teachers; and, to satisfy the religious needs of the community in the south, they might have composed small treatises, not as the sacred canon, which, as they understood that term, was lost beyond recovery, but as mere memory-notes of what they had received traditionally from their teachers; and it is to this class of literature that the works of authors like Puṣpadanta, Bhūtabali, Vaṭṭakera, Kundakunda and Śivārya belong. Their works are written in a language, which inherited many dialectal characteristics of AMg., in which the traditional canon was originally preserved; why, between the works of these authors and the works of the Śvetāmbara canon, we have many common ideas, nay common verses;[1] these common verses do not imply mutual borrowing, but prove a common heritage of both. These things clearly explain the AMg. elements in Jaina Śaurasenī. The strong Śaurasenī colour must have been due to central Indian influence; and, as the Digambaras continued their literary activities in the extreme South, their dialect could remain immune, at least for a long time, from the onslaughts of Māhārāṣṭrī. That the Digambaras were partial to Śaurasenī is also clear from the manner in which they enriched the Kanarese vocabularly under Prakritic influence; and when we see forms like *sakkada* = *samskṛta* in Kanarese, we are tempted to say that it was Śaurasenī grammar that helped them to transform Skt.

1. The problem raised by common verses between *Mūlācāra* and *Āvaśyaka-niryukti*, and between *Prakīrṇakas* and *Bhagavatī-Ārādhanā* will be taken up in a separate paper.

words and then to import them into Kanarese.[1] Further, the Skt. influence on Jaina Śaurasenī can be easily explained by the fact that the Jainas, in the south, were soon driven by circumstances around to adopt Sanskrit; and we find that Jaina authors like Samantabhadra, Pūjyapāda, Anantavīrya, Akalaṅka and others cultivated chaste Sanskrit. This strong inclination towards Skt. and the absence of the reservoir of the AMg. canon brought Jaina Śaurasenī under Skt. influence. The Śvetāmbaras in the North could not show much influence of Skt. on their Prakrit, because they constantly studied their canonical works and post-canonical ones like *nijjuttis* and *cūrṇis*, all in Prakrit, which were sufficiently large in bulk; and moreover they took up Skt. rather late. Just as the Jaina Śaurasenī is influenced by Skt., so the Sanskrit used by Śvetāmbara writers, because of their partiality towards and constant study of their texts in Prakrits, is greatly influenced by Pkt. idiom; and that is why we find non-Sanskritic elements in many of the Śvetāmbara Skt. works. The conspicuous absence of Deśī words in Pravacanasāra, possibly indicates that the Jaina Śaurasenī was nourished, or rather preserved, in the extreme South, isolated from the growing vernaculars of the Aryan tongue in the North; and further, the South Indian vernaculars like Tamiḷa, Kanarese etc., perhaps phonetically, or due to small stock of vocabulary in early days, were inadequate to give loan words etc.; while the AMg. canon in the north was being nourished on parallel lines with the growing vernaculars and hence the possibility of more Deśī words etc. therein. I would call these early Jaina Śaurasenī works as the pro-canonical works of the Jainas.

Now remains one point as to relation of Jaina Śaurasenī with the pre-classical Prakrit postulated by Dr. Jacobi.[2] Māhārāṣṭrī, as its name possibly indicates, had its cradle in Mahārāṣṭra, though it is difficult to define its boundaries at the beginning of the Christian era. It was from the region of its birth that it must have spread into Northern India. It does not appear in the dramas of Bhāsa, but, by the time of Śūdraka and Kālidāsa, its place appears to be recognised for verses. This comparatively late appearance of Māhārāṣṭrī in literature does give rise to a question as to what possibly might have occupied the place of this dialect. Dr. Jacobi postulates that there must have been some Prakrit, which he calls pre-classical Prakrit; and further he shows that he finds the traces

1. The apabhraṃśa-prakaraṇa, chapter VIII, of the Kannaḍa grammar, *Śabdamaṇidarpaṇa* of Kesirāja, gives rules of corrupting Skt. words; these rules remind us of similar ones in Prakrit grammars, some of which are special to Śaurasenī.

2. Dr. Jacobi, *Bhavisatta Kahā* von Dhanapāla, pp. 81*-89*.

of this Prakrit dialect in the Nāṭyaśāstra of Bharata. This pre-classical Prakrit was marked by the optional retention, change or loss of intervocalic consonants; by the softening of *t* to *d* and the gerund in *iya*; and by some kinship with the dramatic Śaurasenī: and also, according to Dr. Jacobi, it shows some traces of Māhārāṣṭrī in the Loc. sg. in *-ammi* and gerund in *ūṇa*. But, in view of the fact that the Śaurasenī of the fragments of Buddhistic dramas does not yet show the softening of *t* to *d*, Dr. Jocobi suspects that originally it must have been foreign to dramatic Śaurasenī, but later on adopted therein from the pre-classical Prakrit, partial glimpses of which are traceable in Nāṭyaśāstra. This postulation of pre-classical Prakrit is really ingenious and explains many otherwise conflicting facts; but the question remains whether Dr. Jacobi would have come to these very conclusions, if he had compared the Pali phonology with his postulated pre-classical Prakrit. This he has not done. The so called old Śaurasenī elements in the fragments of Buddhistic dramas can well be possible in Pali, such as the retention of intervocalic consonants, the change of *ny* to ññ and so forth; in almost all the three dialects called Old AMg., Old Śaurasenī and Old Māgadhī by Dr. Lüders,[1] we find that there is no tendency towards cerebralisation of *n*; and this might be a Pali influence on the various dialects, as a whole, as handled by Aśvaghoṣa. What then is the relation of this postulated pre-classical Prakrit with the Jaina Śaurasenī? The so called specialities of this pre-classical Pkt. are practically found in Jaina Śaurasenī, as we have analysed it from the gāthās of Pravacanasāra. The postulate of Jacobi has one disadvantage that the dialectal facts from Nāṭyaśāstra will have to be accepted with caution; of this he himself is aware, and makes sufficient concession for Sanskritisms and scribal errors.[2] The so called antiquity of the orthography, *hṇ* rather than *ṇh*, might be merely the scribe's habit of writing Skt. Comparing the dialectal stage represented by Nāṭyaśāstra with that of Pravacansāra, one is struck with close similarities; if Sanskritisms like *viśuṣka bhramarāvalī, sahasra, yuvati* etc. are taken to be, and they are, chronologically late features imposed on the pre-classical Prakrit, then the Jaina Śaurasenī, which exhibits comparatively less Sanskrit influence, might represent chronologically an earlier stage than that of Nāṭyaśāstra. And I think, that the dialectal characteristics of this pre-classical Pkt. will have to be decided by a comparison of common verses between the Śvetāmbara canon in AMg. and the pro-canonical literature of the Digambaras, without ignoring,

1. Dr. Lüders, *Bruchstücke buddhistischer Dramen*, pp. 33-64.

2. The Prakrit verses have been lately critically edited, see IHQ. vol. VIII, iv.

of course, the Pali parallels; and the results are sure to be reliable, because these two tracts of literature have been preserved independently and with a remarkable mutual isolation.

The cumulative effect of the dialectal stage of Jaina Śaurasenī on the probable period of Kundakunda, the author of Pravacanasāra, will be touched upon elsewhere.

A. N. Upadhye

॥ श्रेयांसि बहुविघ्नानि ॥

CRITICAL STUDY OF THE WORKS OF BHĀSA WITH SPECIAL REFERENCE TO THE SOCIOLOGICAL CONDITIONS OF HIS AGE AS REVEALED IN THOSE WORKS*

Note: The references are to the "Trivandrum Sanskrit Series" editions of Pratijñā (Pry), Bālacarita (B), Avimāraka (Av.), Karṇabhāra (K), Dūtaghaṭotkaca (Dgh) and Ūrubhaṅga (Ū). For Pañcarātra (Pañc) and Madhyama (Mv), texts with commentaries by T. Ganapati Sastri, 1917, are used, while for similar editions of Pratimā (Prat), Svapnavāsavadatta (Sv), Cārudatta (Cār) and Dūtavākya (Dv) the years of publication are respectively 1924, 1924, 1922 and 1925. Lahore edition, 1930, is used for Abhiṣeka (Abh).

I

AUTHORSHIP OF THE PLAYS.

The discovery and publication of the thirteen plays ascribed to Bhāsa in the Trivandrum Sanskrit Series will go down to posterity as the most epoch-making landmark in the history of Sanskrit Drama. Much has been written in support as well as against the Bhāsa theory. Opinion is yet sharply divided, and nothing like a definite solution of the problem seems to have been reached.

Nearly all the supporters of the Bhāsa theory and some of the antagonists believe in a common authorship of these plays. I have dealt with the problem under twenty main divisions with numerous sub-heads and illustrations from the texts, and have concluded from the cumulative effect of the evidence that all the plays proceed from one and the same author.

Prof. Devadhar[1] who vouches for the common authorship of the plays rules out Cār; but we have shown it to possess many common characteristics. Mr. Jahagirdar[2] classifies the plays in two groups, owing to differences in style, proportion of metre, etc.; but the arguments are insufficient, and the apparent differences can be satisfactorily explained on the grounds of exigencies of the Rasas, and the plays being the products of different periods in the poet's

* Based on the V. N. Mandlik Gold Medal Essay for 1932.

1. Plays ascribed to Bhāsa, pp 19-20.
2. Ind. Ant., 1931, 41-45.

career.[1] All the Mahābhārata plays[2] are very closely related and it is difficult to see how Prof. Dhruva[3] assigns Mv and Pañc. only to the authorship of Bhāsa. The discrepancies in Prat. and Abh.[4] are due to the fact of the latter being an earlier work,[5] written in haste, probably to celebrate the coronation of the patron King of the poet. The verse त्रेतायुगं etc., fits in suitably in Abh,[6] and not in Prat, as is maintained by Prof. Dhruva.[7]

II

AUTHORSHIP OF BHĀSA AND AUTHENTICITY OF THE TRIVANDRUM PLAYS.

The fate of Bhāsa seems to be a peculiarly unhappy one. So long, the loss of his works was deplored; but now that the works have appeared before the public, they are "assured to be compilations and adaptations".[8]

1. Svapna and Svapnavāsavadatta: The mss. of Sv[9] and the Śakuntalāvyākhyā[10] prove that 'Svapna nāṭakā' 'Vāsavadattā nāṭikā, and 'Svapnavāsavadatta (o-ttā)' are the names of one and the same play.

2. *The following are the direct references*[11] to a Svapnavāsavadatta in their chronological order: (i) Ācārya Ābhinavaguptapāda. 10th cent. (ii) Bhojadeva. 11th cent., (iii) Śāradātanaya. 12th cent. (iv) Sarvānanda. 12th century. (v) Rāmacandra and Guṇacandra, end 12th cent. (vi) Sāgaranandin. 13th or 14th century. (vii) Śakuntalāvyākhyā. 14th century. All the above authors refer to one and the same Sv; and in some cases, the printed Sv represents a different (*i.e.*, Southern) recension of the text. The quotation in Kāvyādarśa (II. 180)[12] without mentioning the work or author, seems to be from a northern recension of Sv, its place in our text being after VI. 17. Rāmacandra and Guṇacandra in their Nāṭyadarpaṇa speak of Bhāsa as the author of the Sv, and hence Bhāsa is the author of the group.

1. This answers also Dr. Barnett (Bull. Sch. Ori. Studies, 3, 107-108, 521) Pisharoti (B SOS, 3. Bhāsa's works: A Criticism) Woolner (Thirteen Triv. Plays. Oxford, Vol. I, intr.) and others.
2. Mv. K, U, Dv. Dgh and Pañc.
3. Pratimā, Ahmedabad, intr., p. 92.
4. op. cit., pp. 17-20.
5. Please see post "chronological order."
6. Please see post "Bhāsa verses".
7. Pratimā. Ahm, intr., p. 29.
8. Keith, Bull. School Ori. Studies, 3, 295.
9. Ganapati Sastri, Critical Study, p. 18. Sarup, Vision, preface, p. 1.
10. Unpublished MS in Govt. MSS Library, Madras, R. No. 2778; referred to in Abh. intr. p. VIII.
11. They have all been considered in my original essay.
12. मृतेति प्रेत्य सङ्गन्तुं यया मे मरणं मतम् । सैषावन्ती मया लब्धा कथमत्रैव जन्मनि ॥

3. *References to Bhāsa.*—(*i*) *Rājaśekhara*[1] also says of Bhāsa's authorship of Sv among a number of plays. The stanza is a genuine one from Rājaśekhara, but the context of the verses in the Kavivimarśa is shown to be a recent forgery.[2] Assuming the whole context[3] to be genuine, the stanzas would be made to yield some meaning if 'भासः' in 'धावकोऽपि हि यद्भासः' is taken to mean 'भासः इव' (as if Bhāsa, like the genuine Bhāsa); the comparison between Dhāvaka and Bhāsa seems to have been instituted on the lines of the genuine Rājaśekhara stanza (*viz.*, सरस्वतीपवित्राणां etc., and अहो प्रभावो वाग्देव्याः etc.) and on account of the modelling of Priyadarśikā, Ratnāvali (ascribed to Dhāvaka)[4] on the Sv and Pry. In the next stanzas (आदौ भासेन etc.) the poet apparently identifies Bhāsa with Dhāvaka, but the first stanza reminds us that the *modern* Dhāvaka is compared with *ancient* Bhāsa.[5] The last stanza भासनाटकचक्रेऽपि etc., brings together all the works (नाटकचक्र) of Bhāsa (the ancient, as well as the modern, *i. e.* Dhāvaka) and pronounces its judgment in favour of the Sv.

(*ii*) *Bāṇa*: सूत्रधारकृतारम्भैः etc: The statements in the verse *generally* apply to the Trivandrum plays as Bāṇa simply wanted to compare Bhāsa's plays with temples "in the same words with some not very obvious object of comparison."[6]

(*iii*) *Vākpatirāja* evidently refers to the author of our plays as भास ज्वलनमित्र.

(*iv*) The scenes in which Santuṣṭa, Maitreya, Vasantaka, Śakāra, Sudhākāra, Madhyama etc., are presented will show that our plays contain sufficient humour and hence Bhāsa is the author of the Trivandrum plays according to *Jayadeva,* who says भासो हासः।

4 *Some Bhāsa verses*: तीक्ष्णं रविस्तपति etc. has been ascribed to Bhāsa in Śārṅgadharapaddhati and the ascription is not doubted by Dr. Weller, Dr. Sarup and Dr. Thomas.[7] This verse shows close connection with Av IV. 9, thereby indicating common authorship. Prof. Kuppuswami Sastri[8] quotes the following from Abhinavagupta:

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1. भासनाटकचक्रेऽपि छेकैः क्षिप्ते परीक्षितुम् etc., in the Sūktimuktāvali.
2. Ind. Hist. Quart., 1, 361; 370-78.
3. कारणं तु कवित्वस्य etc., । आदौ भासेन रचिता etc., । तस्य रत्नावली नूनं etc. नागानन्दं समालोक्य etc., । उदात्तराघवं नूनं etc., । शोकपर्यवसन्नास्य etc. । and finally भासनाटकचक्रेऽपि etc.
4. Ind. Hist. Quart. 1, 373; Sarup, Vision, intr., 22-23.
5. Cf. potter Droṇa compared to Vyāsa and Mātanga Divākara to Bāṇa and Mayūra in Rājaśekhara stanzas (given in JBRAS, 17, 57-71).
6. Keith, Sanskrit Drama.
7. Respectively in: Festgabe Jacobi, 117, 120-22; Vision, intr., 3; JRAS, 1921, 884-85.
8. Āscaryacūḍāmaṇi, intr. 25.

अधुना रौद्रं लक्षयति । . . . महाकविना भासेनापि स्वप्रबन्धे उक्तम्,

त्रेतायुगं * * * तद्धि न मैथिली सा
रामस्य रागपदवी मृदु चास्य चेतः ।
लब्धा जनस्तु यदि रावणमस्य कायं
प्रोत्कृत्य तन्न तिलशो न वितृप्तिगामी ॥

This verse is not found in the Trivandrum plays. Context renders it probable that it must refer to some Rāma play and Prof. Dhruva[1] connects the verse with Pratimā after Bharata's speech (भरतः — कथम् । हृतेति (मोहमुपगच्छति)[2]. I do not think the verse fits in with the sentiments of Bharata expressed in that speech or later on. I find a suitable context for the verse in Abh. after II. 15 after अहमेवार्यरामस्य कार्यं साधयामि,[3] which (कार्य) is to cut Rāvaṇa to pieces. (तिलशः प्रोत्कृत्य). The verse is cited as an instance of Raudra and the sentiment in the suggested context is also the same. If the context indicated by me be correct, Prof. Dhruva's objection to Bhāsa's authorship of Abh.[4] becomes answered. Thus the two above-mentioned verses also go to prove genuine Bhāsa elements in the Trivandrum plays.

5 *Some contrary views*: (*i*) *Bhāsa* v. *Śaktibhadra* need not be considered in view of Paranjape's article.[5] Śaktibhadra himself testifies against such ascription, stating that there was no Sanskrit Drama in Kerala before his time,[6] while our plays are referred to long before that time.[7] (*ii*) *Śūdraka* ?[8] As we have shown later[9] that Cār. is the original of the Mṛcchakaṭika, Śūdraka cannot be the author of the group. (*iii*) *Kerala Influence* ? No strong case is made in support of the Kerala origin, as some Prakrit words would not prove Kerala influence,[10] nor would small details[11] which could very well be found anywhere in India. Mr. Kavi, an anti-Bhāsaite, asserts on the contrary that these dramas show no Kerala influence.[12] They show quite a different character from the Kerala Sanskrit in general.[13] Further, these plays were well known in Kerala since the

1. Pratimā, Ahmedabad intr. 29.
2. Act VI. p. 115, line 13.
3. Abh. Lahore, p. 27.
4. Pratimā, Ahm. inter. 17–23.
5. Ann. Bhand. Inst. 9, 1–9.
6. Āscaryacūḍāmaṇi—प्रस्तावना. (Śaktibhadra—10th Cent.)
7. Cf. Bāṇa, 7th Cent.
8. A. R. Sarasvati, Quart. Journ. Myth Society, 12, 268–82 ; K. G. Sankar, Asutosh Mem. Vol. 2, 41–64 ; Caturbhāṇī, Patna, intr.
9. Chap. V.
10. Raja, Journ Ori. Res. 1, 217–45.
11. Shama'a, 4, 267, 289, 290, etc ; 5, 279, 283, etc.
12. Journ. Andhra Hist. Res. Society, 2, 143.
13. *Cf.* Thomas, JRAS, 1928, 881.

last ten centuries. Had they been the works of some Kerala dramatist, at least one of the various anthologists and rhetoricians might have embodied his name while quoting verses from these plays.

(*iv*) *Adaptations or Compilations*? That these plays cannot be called adaptations or compilations has been shown in a convincing manner by Dr. Winternitz.[1] The existence of Sv and other dramas of the group prior to the 7th century A.D., *i.e.*, before the stage reform in Kerela began, renders the theory of adaptations or compilations by actors or Pandits quite untenable, especially as Sv, the most popular piece on the stage, has undergone no great transformation.[2] The Cakyars, again, stage only select acts with necessary changes.[3] So, the particular act would be adapted for the stage and not the whole dramatic work, and hence the latter cannot be set aside as an adaptation. Further, we find that all acts in these plays present the same features of style and thought, which would be impossible if some particular acts were from the stage editions and the rest from the original. It seems that our plays are called adaptations simply because they are anonymous, as Āscaryacūḍāmaṇi, Nāgānanda, though belonging to the Cakyar repertoire are not called adaptations.

III.

DATE OF BHĀSA.

Date of Bhāsa is one of the most vexed questions in Indian Chronology and a difference of over 1500 years is found in the earliest and latest dates assigned to him.[4]

Internal evidence fixing the upper limit is the following: (*i*) The sources of the plays are the Rāmāyaṇa, Mahābharata and folklore.[5] The characters in the Udayana plays are historical belonging to the 6th Century B.C. and the Mahābhārata and Rāmāyaṇa[6] were existing then. (*ii*) Enumeration of the historical families in Pry and Av whose memories were lost in the Mauryan period,[7] mention of Rājagṛha being the capital, show a period closely allied with the 6th century B.C. References to Nāgavana, Veṇuvana, etc. place the poet in the post-Buddhistic period *i.e.*, after the 6th century

1. Bhagavadajjukīyam, Preface, vii. Also, Thomas, JRAS, 1925, 106-07, 1928, 877.

2. Thomas, JRAS, 1928,877--890,

3. *E.g.* मह्राड्डक, शेफालिकाड्डक, मन्त्राड्डक etc. G. Sastri, BSOS, 3, 634. Pisharoti, JBARS, 1925, 250.

4. Cf. Festgabe Jacobi, 127; JBRAS, 26, 233.

5. Please See Chap. IV.

6. Macdonell, *History of Sanskrit Literature*, pp. 285, 309.

7. Since all those small kingdoms were conquered and included under one empire by Mahāpadma. *Cf.* H. Sastri, Prabuddha Bhārata, 1929, 131.

B. C. (*iii*) Various Śāstras are mentioned in the Prat;[1] all of them are of fairly old antiquity, at any rate, prior to the 6th century B. C. (*iv*) Sociological conditions[2] show many parallelisms with Jātakas and Arthaśāstra, assigned to the 5th-4th century B. C. (*v*) Language evidence (*e.g.*, archaisms etc.) shows Bhāsa to have flourished before Pāṇini's grammar (650 B. C.) got a strong foothold. (*vi*) The epilogues speak of an emperor ruling over the whole of Northern India. Ugrasena Mahāpadma was "the founder of a first real Indian Empire."[3] Possibly he was our poet's patron.

Thus, the internal evidence points to a period between 5th-4th century B. C.

External evidence: Last chapter brings us to the 7th century A. D. (Bāṇa). Next in the chronological order are Vāmana and Śūdraka. (*1*) *Kundamālā* (5th century A.D.) clearly refers to Prat, that being the only play where statues, and especially that of Daśaratha, are mentioned.[4] (*2*) *Cilappadikāram* (3rd—2nd century A. D.)[5] of Ilankodigal refers to a Bālacarita. The passage speaks of the Kuravai dance which Kṛṣṇa of old danced in Gokula. The word 'Bālacarita' in the passage is purposely used clearly suggesting a drama of that name.

It may be contended that the reference may be to another Bālacarita; but we have not yet come across any other Bāl, and in fact there are no dramas dealing with the same topic, in Sanskrit, which bear identical names.[6] The verse quoted by Viśvanātha[7] *viz.*, उत्साहातिशयं वत्स etc., is quite insufficient to postulate another Bāl by Bhāsa. The verse can very well find a place in our Bāl at p. 42 after the last speech of Dāmodara and before the stage-direction सङ्कर्षणस्तैः सह निष्क्रान्तः It seems the commentator of Viśvanātha[8] is unhappily wrong in his prefatory note to the verse. I think the above context suits the verse.[9] (*3*) *Aśvaghoṣa's* verse (1st century A. D.) seems to be borrowed and worked over. (*4*) *Kālidāsa* (1st Century B. C.) speaks of Bhāsa as प्रथितयशस्, indicating lapse of much

1. Prat. p. 99. cf. Keith, BSOS, 3, 295, 623-25; Winternitz, Cal. Rev. 1924 348; Sukthankar, JBRAS, 1925, 131-32.

2. Please see Chap. VI.

3. Ghosal, Mod. Rev., 1930, 438. Roy Chowdhury, Pol. Hist. Anc. India, 141-142.

4. पडिमागदो महाराओ (p. 10). Contra, Kane. Annals Bhand. Inst. 10, 155.

5. Abh. Lahore, Intr. V. All India Drama Conference, 1921, 165.

6. Thomas, JRAS, 1925, 106-07, Winternitz, Problems, p. 122.

7. Sāhityadarpaṇa, Kane's edn., App. E, p. 73.

8. Cf. Ganapati Sastri, Critical Study, p. 21.

9. The prefatory note reads: 'रामं प्रति दशरथस्योक्तिरियम्.' It is but natural that Saṅkarṣaṇa would address Dāmodara as वत्स. Cf. also अलमलं भयविषादाभ्याम् p. 49.

time between the two. Finally, (5) *the Arthaśāstra* (4th century B.C.) supplies us with the last link.[1] Bārhaspatya Arthaśāstra mentioned by Bhāsa is one of the works used by Kauṭilya in writing his Arthaśāstra. So, perhaps, Bhāsa and Kauṭilya might have borrowed from the same source.

Thus, a consideration of the internal and external evidence gives us the 4th century B. C. as the probable date.

Argumentum ex silentio by itself is of no avail. Non-mention of the following facts in Bhāsa goes to strengthen our conclusion already arrived at by other sources.

(i) Complete ignorance of the poet of the topography of South India beyond Vindhya and Narmadā places the poet before Candragupta's conquest of the South.[2] (ii) Non-mention of 'nāṇaka', but mention of the general terms 'suvarṇa' and 'māṣaka' shows the poet considerably prior to the 2nd century A.D.[3] (iii) Non-mention of Rāśis at proper occasions when nakṣatras are mentioned, places the poet before the Hellenic influence through which Rāśis entered Indian Astrology.[4] (iv) Mention of the Jain mendicants as naked shows that the poet was ignorant of the other sect. The schism originated at about 300 B.C., and hence the poet flourished before this period.[5]

Thus, the evidence at our disposal places Bhāsa in a pre-Mauryan period, possibly as a senior contemporary of the great Mauryan Emperor, Candragupta.

IV

CRITICAL STUDY

1. Text material of the Plays: Different editions[6] of Sv, Prat, B, Pañc, Av etc., have been brought out, but they all represent the Southern MSS which do not materially differ from the MSS used for the Trivandrum Texts. The northern recension of the plays, if found, would throw a flood of light on the problem.

2. Sources of the Plays: Dv, K, U, and Pañc follow the Mahābhārata in the main, the poet adding some incidents here and there. The plot of Dgh is the poet's invention, the epic supplying him with the characters only. Mv is based on an incident from the Aitareya

1. Pry. IV. 3 Arth. X. 131, p. 368, Mysore Edn. Please see also Chap. VI.
2. Roy Chaudhury, Pol, Hist. Ancient India, 1927, p. 168.
3. Cf. K. G. Sankar, Asutosh Mem. Vol. 2, 62.
4. Mod. Rev., 1929, 254.
5. Camb. Hist. Ancient India, 1, 165.
6. List given in bibliography 'A'. Prof Pisharoti in translating Sv. Prat (Quart. Jnl. Mythic Soc.) Dgh and Av (Shama'a) has given variants to the Trivandrum readings from the MSS available to him. Prof. Dhruva in his translations of Sv. Pry, Mv and Prat (text also) proposes various emendations which unfortunately are wholly conjectural, unsupported by the MSS.

Brāhmaṇa.[1] An earlier version of Harivaṁśa or Bhāgavata may have been the source of B. As to Prat. and Abh. the indebtedness to Vālmīki cannot be denied. The story of Sv and Pry was taken from folklore and not from Bṛhatkathā.[2] No definite source has been found for Cār. The main story of the Av. was extracted from folklore and the supernatural element was added by the poet.[3]

3. *General Observations on the Plays:* (*i*) *Characterization.* Bhāsa being a realist portrays men and women of this world. They are individuals not types. Every character is a psychological study. The intricate workings of the human emotions are shown by a flash.[4] In all, nearly 240 characters are employed, B claiming the highest number and K the minimum. The characters speak neither more nor less.

(*ii*) *Style and Dialogues:* The language is very simple, natural and touching, alternated with simple figures of speech like simile and metaphor. The sentences are generally never long. Prasāda, oja and mādhurya may be said to be the characteristics of Bhāsa's style. At times, the style is ornate or alliterative, as befits the occasion and sentiment.[5] The dialogues show that Sanskrit was a spoken language at that time. The speeches are natural, realistic, vigorous; there is nothing of bookishness or unnecessary predominance of figures.[6] Verse is successfully employed in some dialogues.[7]

(*iii*) *Rasas and Alaṅkāras:* The poet has a special liking for the vīra, karuṇa, hāsya and vatsala (Sāhityadarpaṇa III. 251) Rasas. Śṛṅgāra is very sparingly employed (only in Sv and Av) showing thereby that a dramatic piece can appear at its best without the erotic element. As to the figures of speech, Bhāsa is content only with the simple ones—Upamā, Utprekṣā, Rūpaka, Arthāntaranyāsa, Anumāna, etc.

(*iv*) *Descriptions of Nature, etc:* Bhāsa being a close observer of nature, his descriptions are interesting and realistic. He gives diverse details and various facts connected with the phenomenon he wishes to portray.[8] He paints nature as sympathising with the feelings of the person that observes it.[9] Besides nature, the poet has

1. 7. 3. Dhruva, Madhyama, intr. 12-16.
2. Cf. JAOS, 43, 169.
3. See BSOS, 3, 591; Ind. Ant., 1931, 113-115; Hindusthan Review, 1927, 118.
4. *e. g.* Vāsavadattā in Sv. Act III.
5. Nāṭyaśāstra, 16, 105-109.
6. Cf. dialogues esp. in Sv, Av, Ū.
7. Av II.6, III. 14, VI. 21; Pry I. 2; B V. 10; Pañc II.34, 37; ū 21, 66; Prat I. 31; III. 1, 14; IV. 24; VII. 14; Abh. VI. I, 5.
8. Sv. I. 19; B I. 16, 19; Cār. I. 20.
9. Av. II. 13; IV. 4, 5, 7, 11, 12. Prat III, 2.

shown his mastery in giving vivid, accurate, realistic account of battle.[1] Mention may also be made of the descriptions of the sacrifice and the sacrificial fire, night, and darkness.[2]

(*v*) *Bharatavākyas:* The change in the toning of the Bharatavākyas shows that they refer to some particular King. Taking into consideration the ignorance of the poet about the trans-Vindhyan countries and the territorial description in the epilogues, there remain only two claimants for the title of Rājasiṁha[3]—*viz.*, Ugrasena Mahāpadma and Candragupta. As our poet was somewhat prior in time to Kauṭilya, he seems to be the court poet of Ugrasena Mahāpadma,—or a senior contemporary of Candragupta.

(*vi*) *Anachronisms*: Late date was assigned to these plays on account of (1) the mention of statue houses and मेधातिथेर्न्यायशास्त्रम् in Prat., (2) deification of Rāma and Kṛṣṇa in Abh. and B.,[4] (3) mention of Kharapaṭa in Cār.,[5] (4) naming a Brāhmaṇa as Keśavadāsa in Mv,[6] and (5) the use of metronyms in some of the plays. All these can be shown not to be real anachronisms. (1) The erection of statue houses was an ancient custom and Medhātithi was Medhātithi Gautama. (2) Kṛṣṇa was worshipped in the 4th century B.C.[7] and his deification must have been a slow process. Similarly with Rāma.[8] (3) Kharapaṭa was an ancient master even at the time of Kauṭilya.[9] (4) शर्मवद् ब्राह्मणस्य स्यात् (Manu II. 32) is not an ancient rule invariably followed. (5) Metronyms are found in ancient Sūtra works and Upaniṣads. The words 'Svāmin', 'Bhartṛdāraka' in some of these plays cannot show their posteriority to the Kṣatrapas,[10] since the terms were in use long before the latter's time.[11] Thus, the so called anachronisms are non-existent. I could not come across any instance of a real anachronism.

(*vii*) *Defects*: (1) Disregard of the unity of time is the first drawback that would strike one after a study of the plays.[12] (2) Another defect of the same kind is found in the use of निष्क्रम्य प्रविश्य.

1. Abh. VI. 1-18; U 16-26.
2. Pañc I. 3-19; U 4-14; Av. pp. 43-46; Cār pp. 25-26; B pp. 7, 9.
3. Cf. Konow, Das ind Dr., 1920, 51-56; Jayaswal, Journ Asiatic Soc. Bengal, 1913, 264-65; Dhruva, Svapnanī Sundarī, intr, p. 12, 30-59.
4. Winternitz, Problems, 123.
5. Devadhar, Plays etc., 36-37.
6. Kane, Vividhajñāna Vistāra, 1920, 97-103.
7. Macdonell, Hist. Sansk. Lit. 411.
8. G. Sastri, Critical Study, 66-68.
9. G. Harihar Sastri, Asutosh Mem. Vol. 1, 224-27.
10. Levi, Ind. Ant. 33, 163.
11. Kane, Sāhityadarpaṇa, intr., VIII-IX.
12. Cf. B. प्रभाता रजनी (p. 18) and तथैव प्रसुप्तो...जनः (p. 20); Av. आरूढा ज्योत्स्ना (p. 42) and अर्धरात्र, कालरात्रि (p. 43); Sv स्थितोमध्याह्नः (p. 24) and I. 16; also the tithi scheme in Cār.

This appears quite unnatural, repugnant to the sense of proportion of the spectators. (3) The device of Ākāśabhāṣita though minimising the number of characters takes out the elements of reality and naturalness from the dramatic piece. The method is not impressive, though of practical utility from the point of stage economy. (4) The entry of characters quite unannounced is also a defect. (5) Grammatical solecisms, faulty versifications, etc., may be justified on the grounds of epic usage and influence; but some verses are found quite plain and devoid of any sentiment or poetic fancy.

4. *Personal History of Bhāsa*: Nothing is known about Bhāsa except what little can be inferred from his works. Bhāsa is held to be the gotra of the poet who was an orthodox Brāhmaṇa, a staunch up-holder of the sacrificial system. He seems to be a Northerner.[1] He was a Vaiṣṇava, and a follower of the Pāñcarātra system, well-versed in the science of politics, music, fine arts, dramaturgy, and a close student of the epics. He seems to have been a court poet to some king, not a king himself.[2]

5. *Other Works of Bhāsa*: Bhāsa is credited with thirty or twenty-three dramas[3] and a work on dramaturgy.[4] *Ghaṭakarpara* ascribed to Bhāsa cannot be his work as the identity between Ghaṭakarpara (the author of the Kāvya of that name) and Bhāsa is not established, and the manner and matter of the work[5] tell strongly against the authorship of Bhāsa as it is full of yamakas and the erotic element. *Viṣṇudharma* is said to be a poetic work by Bhāsa[6]; but the verse containing the reference simply records the tradition of the fire-ordeal. *Dāmaka* and *Traivikrama* are recently attributed to Bhāsa.[7] The former would serve as the best illustration of a 'compilation,' traces of borrowings from different sources being perceptible everywhere.[8] By no stretch of imagination are we able to apply the term "drama" to Traivikrama.[9] There is no plot,

1. Cf. ignorance of south; all characters from north; use of tālī-patra in Cār. etc.

2. Contra Sankar, Asutosh Mem. Vol. 2, 61; but the words त्वाम् and ते in the prologues of Sv and Av show simply that the poet was sure of the King's presence at the first performance of these plays.

3. All India Drama Conf. 1927, 131; Priyadarśikā, Srirangam, xxii; Lokaśikṣaṇa, 1917, 325.

4. Keith, Sanskrit Drama, 105; Sarup, Vision, intr. 37. अर्थद्योतनिका speaks of it.

5. घटकर्परकाव्यम् pub. श्रीवेङ्कटेश्वर प्रेस, मुंबई, शके १८३१, is the same since it contains verses (e.g. हंसपङ्क्ति and आलम्ब्य Nos. 9 and 10) said to belong to घटकर्परकाव्य.

6. Ind. Ant., 1913, 52–53.

7. Oriental Conference, III, pp. 80–85.

8. Dāmaka, Lahore, 1926. Jolly, Festgabe Garbe, 115–121.

9. Traivikrama, Shama'a, Madras, 4, 213–222.

no construction, no characterization. It is unique in that it has no prologue, and no characters besides the stage manager and his mistress. Prof. Pisharoti is right in fathering it on Nīlakaṇṭha. Thus, there are at present no other works of Bhāsa besides those published in the Trivandrum series. The catalogues of MSS do not show any works of Bhāsa.

6. *Bhāsa and Nāṭyaśāstra*: Bhāsa is found not following the rules in Nāṭyaśāstra and in some cases disobeying them. The extant Nāṭyaśāstra has been placed between 2nd century B. C.—4th century A. D.[1] *i.e.*, after Bhāsa. Again, the use of the word "Bharatavākya" in these plays need not speak of their posteriority, since the scribes used the word.[2] That the poet knew a *Nāṭyaśāstra*[3], shows that it was quite distinct from the Naṭasūtras of Pāṇini. Bhāsa is credited with having written a work on dramaturgy. So, possibly, he followed his own rules or some prior Nāṭyaśāstra (either by Bharata's predecessors or an earlier version of Bharata) which we have not been able to acquire as yet.

7. *Tragic Sense in Bhāsa*: Ūrubhaṅga is a tragedy viewed from Aristotle's point or that of Hegel. It does not depict the victory of Kṛṣṇa.[4] Duryodhana is not portrayed here as an evil person, but he is the real hero, quite distinct from his Mahābhārata-characteristics. Throughout the play we find the poet always sympathising with his hero, evidently Duryodhana, and pictures the conflict as of right with the right and that the conflict was not only inevitable but necessary in the ends of justice.

Bhīma's victory over Duryodhana in the club fight is due to wile. Further, the latter invokes our sympathies gradually.[5] Duryodhana is portrayed as a true son. Though fallen, he is not crest-fallen and prides in that he did not show his back in war. Duryodhana rouses our sense of pity by undeserved misfortune. The tragic element in Ū would be seen in a clearer light by its comparison with Veṇīsaṁhāra where Bhīma is the real hero and Duryodhana does not attract the sympathies of the spectators.

1. Haraprasad Sastri, 2nd B.C.; Kane and Keith 3rd B.C.; Dhruva 4th A. D.

2. Cf. Ind. Hist Quart. 7, 187-190 and other articles on 'Bharatavākyas' in that Magazine.

3. Av p. 16 णट्टसत्थं.

4. Contra. Keith Sanskrit Drama, pp. 38, 96, 106, 278, 354, etc.

5. Cf. He prevents Balarāma who sets up to uproot the Pāṇḍavas. (ū.31); his queens lament (यन्ममापि स्त्रियो रुदन्ति । ū. p. 101); his broken knees prevent him from paying homage to his parents and he has to refuse his thighs as a seat for his son (ū. pp. 103–05).

Veṇīsaṁhāra in reality is a suppressed tragedy. Ū is complete in itself, not the only surviving intermediate act of an epic Drama.[1]

8. Magic in Bhāsa: We get instances of the use of magic by (i) employing objects endowed with magic power, (ii) the curse of a ṛṣi having the desired effect and (iii) the optical illusion. Av and Pry furnish instances of the first kind.[2] The curse of Caṇḍakauśika in Av illustrates the second kind, and the confusion of Duryodhana when seeking to bind Vāsudeva is an instance of the last kind.[3]

9. Verses Ascribed to Bhāsa by Anthologists and Rhetoricians: The non-occurrence of even a single Bhāsa stanza in our plays need not speak of their spuriousness. There are fifteen such stanzas and those of them ascribed to Bhāsa by Dr. Weller, Dr. Thomas or Dr. Sarup are marked as such in the footnote.[4] Dr. Thomas without mentioning the verses says that four stanzas "would not admit of a place in the Trivandrum plays."[5] Dr. Weller has really put forth a strong case and we see no reason to differ from him. पेया सुरा etc. certainly belongs to Mattavilāsa.[6] पादाक्रान्तानि and त्रेतायुगं may find a place in Sv and Abh respectively.[7] I am inclined to doubt the authorship of Bhāsa in the case of कठिणहृदये, कृतककृतकैः and दग्धे मनोभवतरौ, on the ground that the ideas they express are foreign to Bhāsa. प्रत्यासन्नविवाह etc., being a maṅgalaśloka would not get a place in the Trivandrum plays. विरहिवनिता and बाला च सा may be included in Av, though the former, being a description of winter, may, with the description of autumn (तीक्ष्णं रविः), fit in anywhere.

10. Chronological order of the Plays: Chronology in the works of an author explains many apparent contradictions. I have considered the problem from the point of matter and manner of these plays.

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1. Contra. Sukthankar, JBRAS. 1925, 141. 'Aṅka' is a technical term for a kind of drama, hence not necessarily an 'Act'.

2. Av p. 65; Pry, p. 22.

3. Dv. pp. 23-24: JAOS, 45, 110-14.

4. The fifteen verses are: (*i*). तीक्ष्णं रविः W. T. S; (*ii*). दुःखार्ते मयि W. S. (*iii*) विरहिवनिता W. S; (*iv*). बाला च सा W. S.; (*v*). यदपि विबुधैः W. S.; (*vi*). प्रत्यासन्नविवाह T. S.; (*vii*). कठिणहृदये S.; (*viii*). कृतककृतकैः S.; (*ix*). दग्धे मनोभवतरौ S.; (*x*). अस्या ललाटे T. S.; (*xi*). कपाले मार्जारः W.; (*xii*). दयिता बाहुपाशस्य T.; (*xiii*). पेया सुरा; (*xiv*). पादाक्रान्तानि पुष्पाणि and (*xv*). त्रेतायुगं. Thus, in the above verses, according to Dr. Weller, Nos. 1-5 and 11, according to Dr. Thomas, Nos. 1, 6, 10 and 12, and according to Dr. Sarup, Nos. 1–10, may have come from Bhāsa.

5. JRAS, 1928, 883.

6. Trivandrum SS, No. 55, p. 7.

7. Sv. IV. 2A; Abh. II. 15A.

For the former I depend upon metrics and the proportion of dialogues to verses, and for the latter, upon characterization, ideas, ideals, etc.

I find three periods in the career of our poet. The first was of one-Acters where the poet tried his apprentice hand. The plots are taken from Mbh. and the poet has added very little of his own. The epic metre predominates and the proportion of dialogues to verses is very low. Pañcarātra marks a transition in that the poet shows his inventive genius, has increased the number of characters, and the dialogues are on the increase. Just on the heels of Pañc. come B and Abh, as is seen from the similarities of the ideas and expression, use of song and dance, etc. The proportion of epic metre does not militate against the middle period being assigned to these plays. Av again, belongs to the period of transition as it has the proportion of the dialogues much increased and very low percentage of the epic metre. Exigencies of sentiment required the use of other metres. The erotic element suggests that the play may have been a product of the young days of the poet. Prat, Pry, Sv and Cār are the finished products of the final period, which is characterised by minute and psychological characterization, high proportion of dialogues to verses and absence of flaws in the epic metre, its percentage being 40--45. Two of the last mentioned plays have one Act each with no verse at all. Prat does not conform to the dialogue test; but we assign it to this period on other grounds.

11. Bhāsa's Influence: Kālidāsa was a close student of Bhāsa, and Śūdraka has planned at least four acts of his drama on Cār, the last acts also showing many Bhāsa echoes. Bhavabhūti has written Mālatī-Mādhava on the lines of Av; the plots in both being taken from folklore and the descriptions of nature being in the same style. Mudrārākṣasa seems to be under the influence of Pry. Priyadarśikā, Ratnāvalī and Nāgānanda show a considerable Bhāsa influence. Veṇīsaṁhāra shows similar characterization as in Pañc. Prabodhacandrodaya, following B. presents abstract ideas as characters. The influence of Bhāsa on Kerala dramatists is immense. Not only have they imitated his structural peculiarities but his antique Prakrit as well. Bhāsa's Udayana plays are responsible for Viṇāvāsavadatta, Unmādavāsavadatta, Tāpasavatsarāja. Mattavilāsa is indebted to Pry. Āscaryacūḍāmaṇi shows many traces of borrowing from Abh in particular and Bhāsa dramas in general. Tapatīsaṁvaraṇa, Subhadrādhanañjaya, Kalyāṇasaugandhika, Dāmaka, Traivikrama, Bhagavadajjukīya and many other plays from the South have imitated the technique and ideas of Bhāsa.[1]

1. The next section on "Bhāsa's Stage" is omitted.

V

CĀRUDATTA AND MṚCCHAKAṬIKA.

The investigations of Dr. Sukthankar, Morgenstierne, Belvalkar and Paranjape[1] from various points of view should leave no reasonable doubt in our minds as to Cār being older than and hence the original of Mṛ. Accepting Mṛ. as an independent work having no connection with Cār, a careful examination of the later acts, *viz.* VI-X of Mṛ., shows the influence of Bhāsa plays, signifying thereby its posteriority to Bhāsa and hence to Cār.

In spite of the colophon at the end of one of the MSS saying अवसितं चारुदत्तम्, internal evidence is shown to be against it,[2] though one more act will not complete Cār.[3] Sarasvatī kaṇṭhābharaṇa,[4] and Nāṭakalakṣaṇaratnakośa[5] show that Daridra-Cārudatta (or Cār) had a sequel running on very similar grounds to Mṛ.

The weaving of the political byeplot with the main story is the creation of the author of Mṛ.

Under these circumstances, the assertion of some scholars[6] that Cār and Mṛ. are different versions of the same play, appears rather strange.

(i) The evidence of the rhetoricians who quote from both works as quite distinct is against such assumption. Śakuntalāvyākhyā[7] says चारुदत्ते पुनः सूत्रधारस्यापि प्राकृतम् (p. 12.) indicating thereby that the author of Cār was the originator of the device of employing Prakrit in the prologue.

(ii) Again the essential differences between the plays that speak of different periods seem to have been ignored. Such are (1) mention of Nāṇaka in Mṛ. placing it after 2nd century. A.D.; (2) use of musical terms 'mūrchanā' and 'Kākalī' in Mṛ, while Cār has no musical term; (3) long description of the courts of Vasantasenā closely corresponds with Bṛhatkathāślokasaṅgraha,[8] thus indicating a late date for Mṛ; while Cār has only a sentence for the description; (4) full knowledge of planetary astrology relegates the author of Mṛ to a

1. Respectively in: JAOS, 42, 59-74; Über das Verhältnis Zwischen Cārudatta und Mṛcchakaṭikā, Leipzig. 1921; Oriental Conference, I, 189-204; Sāhityasaṅgraha, 1, 102-140.

2. Mehendale, Bhand. Com. Vol. 367-374; Sukthankar, QJMS, 1918, 181-86 etc.

3. Cf. Charpentier, JRAS, 1923, 595-607.

4. शकार ! किं प्रार्थनया etc. given by Dhruva in Svapnanī Sundarī, intr., p.21.

5. JBRAS, 1925, 274-276.

6. Jahagirdar, Ind. Ant. 1931, 42; Raja, Journ. Or. Res. 1, 245; Sankar, Asutosh Mem. Vol, 2, 58; Hiranand Sastri, Mem. Archaeological Survey of India, 28, p. 22.

7. Ind. Hist Quarterly, 1929, 726.

8. Keith. Hist. Sansk. Lit., 271.

later period, as also (5) the sympathetic attitude towards Buddhism; (6) Cār invokes the aid of Kharapaṭa an ancient master, while Mṛ calls others not so ancient.

Thus, both Cār and Mṛ cannot belong to the same period. Mṛ is later and hence an expanded version of Cār. Cār, as we have it, is a fragment and it had a sequel on the lines of which the author of Mṛ has developed its plot with additions and improvements.

VI

SOCIOLOGICAL CONDITIONS

(1) *Introductory.* We have placed Bhāsa in the Mauryan or pre-Mauryan period; and hence it would be important and interesting to note the similarities and differences between the society as depicted in our plays and that represented by the works of that period, of which we take Arthaśāstra[1] and Jātaka[2] stories as typical. References to these two will be made in the foot-notes.

(2) *Geographical Knowledge of the period*: In the Mahābhārata plays are mentioned places which being of very little significance, have not been identified as yet; *e.g.*, यूपग्राम and उद्यामक in Mv. The Udayana plays contain some places that were of local and temporary importance and hence these also cannot be identified with any degree of certainty; *e.g.*, वेणुवन, नागवन, मदयन्तिका, etc.

The places, countries, mountains and rivers mentioned in the plays[3] clearly show that countries to the north of Narmadā were well known, while trans-Vindhyan places were not known.

(3) *Castes, their Relations and Occupations:* The four castes are distinctly mentioned,[4] and they were based on birth.[5] There is no reference to the mixed castes, born of intercaste wedlock and out of the wedlock, so elaborately enumerated by the Smṛti writers. The *Brāhmaṇas* were the caste par excellence,[6] and numerous are the references to them. The sacred thread was the badge and the distinguishing mark of the Brāhmaṇas.[7] The utterance of a Brāh-

1. Ed. Mysore, 1919.

2. Ed. Cowell, Cam. Univ. Press.

3. All the places, countries, etc. are given in the original essay. Pry. II. 8 mentions सौराष्ट्र *viz.*, modern Kathiawar; but one of the MSS reads सैविार, thus throwing doubt on the mention of सौराष्ट्र. लङ्का, किष्किन्धा, मलय, महेन्द्र and सुवेल given in Abh. are copied from the Rāmāyaṇa.

4. वणिक् (Cār Act II.) वृषल (Part III. 5; Pañc I. 6).

5. द्विजो भवान् क्षत्रियवंशजा वयम् । Pañc I. 25. क्षत्रियवंश्यैः पूर्ववैरम् । K. p. 75 Av. I. 7; Prat. p. 61.

6. ब्राह्मणपुरोगासु सर्वे प्रजासु । B. p. 54; III. 16.

7. जण्णोपवीदेण बह्मणो । Av. p. 85.

maṇa was highly respected, even untrue statements were regarded as true and he was never contradicted.[1] The curse of a Brāhmaṇa was supposed to bring calamity.[2] Brāhmaṇas were the preceptors of Kṣatriyas and it was thought disgraceful to the disciple if the guru was poor.[3] Giving away every thing to Brāhmaṇas was a desirable thing and saving a Brāhmaṇa by losing one's body was highly thought of.[4] Feeding Brāhmaṇas in order to propitiate untoward fate and ward off evils was very common.[5] There was a prevalence of Brahmanical rites and ceremonies as also of sacrifices, and payment of fees to the Brāhmaṇas.[6] Though the Brāhmaṇas were the custodians of Vedic learning, a thoroughly ignorant Brāhmaṇa was not a rarity.[7] Though not idealised as in the Jātakas, the *Kṣatriyas* also occupied a high position. The protection of their subjects was their main duty.[8] The *Vaiśyas* are only incidentally mentioned and a reference is made to their travelling in foreign countries and taking a circuitous way for fear of thieves.[9] The passages in which the *Śūdras* are mentioned[10] suggest that untouchability was observed, at least in regard to religious functions. Even the courtesans thought it improper to make a Śūdra youth the object of their love.[11] The Śūdras worshipped the deities without chanting any mantras.[12] The *cāṇḍālas* were outside the caste-system and had their residences outside the cities.[13]

As regards the *relations* between the castes *inter se*, there is nothing to show that they were not cordial. The injunction about

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1. ब्राह्मणेष्वनुत्तरा वयम् । Panc p. 89. ब्राह्मणवचनमनृतमपि सत्यं पश्यामि । B. p. 27. ब्राह्मणवचनमिति । न मयातिक्रान्तपूर्वम् । K. p. 84. The Brāhmaṇas also were equally confident of never uttering a falsehood. B. p. 27.
2. Av. I. 11; p. 96. also Prat. pp. 118–119.
3. Panc. I. 28.
4. Panc. I. 22; also. मच्छरीरेण ब्राह्मणशरीरं विनिर्मातुमिच्छामि Mv. p. 30.
5. Pry. p. 21. भट्टिणा सन्तिणिमित्तं उवट्ठिअभोअणं बह्मणजणं । Cār. p. 6 इच्छेअं... बह्मणं णिमन्तेदुं । p. 84 सव्वसारविभवेण बह्मणेण सोत्थि वाअइदव्वं त्ति । B. I. 25 करोमि विपुलां शान्तिं मम शान्तिर्भविष्यति । cf. Jātakas IV. 450, 484, 489, 497; V. 528, 536, 540; VI. 545.
6. Cār. p. 84; Pry. pp. 48, 50. also Cār. p. 7. ...दक्खिणामासआणि भविस्सन्ति ।
7. Av. p. 16. बह्मणो दुळ्ळहो अक्खरञ्ञो अत्थञ्ञो अ ।
8. K. 47 तस्मात्प्रजापालनमात्रबुद्धया etc.
9. Cār. p. 45 वणिजदारओ कोच्चि आअन्तुओ । p. 77 भीदीए उप्पहप्पवुत्तो विअ वणिजो । also p. 78.
10. Panc I. 6; Prat. III. 5.
11. Cār. pp. 44-45.
12. Prat III. 5 वार्षलस्तु प्रणामः स्यादमन्त्रार्चितदैवतः ।
13. Av. p. 14. Panc. p. 52.

the *occupations* was not strictly followed. We have a Brāhmaṇa as a trader.[1]

4. *The four Orders and their Duties: Brahmacarya:* After upanayana, a Brāhmaṇa boy had to go to a guru for the study of the Vedas.[2] The residence at the preceptor's entailed the performance of bodily labour in the household, bringing fuel, etc.[3] The rule of anadhyāya was followed.[4] There were some students reluctant to live the rigours of celibate life, who looked with the greatest joy to their samāvartana ceremony, after which they hastened home.[5] High ideals of the *gṛhasthāśrama,* which one entered after finishing one's education, are placed before us in the characters of Sv. Prat. Cār, etc. Husband and wife respected each other.[6] We are told of the dowager queen of Magadha who resided in a *hermitage* near Rājagṛha, and a detailed description is given of the tapovana.[7] Everyone was free to go there; everything spoke there of purity and abundance. The tapovanas were not the exclusive preserves of men but were mixed colonies of ascetics.[8] There were two classes of the *Saṁnyāsins,* tāpasa and parivrājaka.[9] Those staying in the hermitage belonged to the former class, and the latter moved from place to place, either alone or with the disciples. The order of the red-garmented seems to have been degenerated as some entered it to gain livelihood.[10]

5. *Marriage Laws and Customs:* Out of the eight forms mentioned in the Smṛtis, we get instances of five forms, *viz.,* Brāhma, Kṣātra, Gāndharva, Rākṣasa and Āsura.[11] *Brāhma and Kṣātra marriages*: For a regular marriage between the Kṣatriyas, envoys and priests used to be sent to the father of the bride.[12] Marriages were entered into after considering the various aspects

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1. Cārudatta. cf. In the Jātakas we have Brāhmaṇas following diverse occupations: agriculturist (III. 354; IV. 467) trader (IV. 442) carpenter (IV. 475).

2. श्रुतिविशेषणार्थं वत्सभूमौ लावाणकं नाम ग्रामस्तत्रोपितवानस्मि Sv. p. 27. Pañc I. 5; Mv. pp. 25-26.

3. Cf. कदाचित् फलमूलसमित् etc. K. p. 75.

4. Cār. p. 41.

5. किदसमावुत्तो बहुओ विअ तुवरसि । Av. p. 73.

6. Prat. I. 10; 25.

7. Sv. pp. 9-26.

8. Cf. Jātakas. III. 348, 418, 436; IV, 509.

9. Rhys Davids. Buddhist India, pp. 140-41. cf. यागन्धरायण in disguise.

10. Sv. I. 9 नाहं काषायं वृत्तिहेतोः प्रपन्नः । Cf. Jātakas III. 322, 353.

11. Brāhma (Padmāvatī and Vatsarāja) Kṣātra (Jayavarmā and Sumitrā) Gāndharva (Avi and Kuraṅgī) Rākṣasa (Vatsarāja and Vāsavadattā) Āsura (Daśaratha and Kaikeyī) आसुरो द्रविणादानात् Cf. Prat I. 15. शुल्के &c.

12. Pry Act. II. Av. Act I.

of the question, 'family relations' being the main consideration, evidently with a view to accord with the rule of endogomy.[1] The qualities of heart and head were secondary factors, as also were the physical features and the strength of the bridegroom.[2] The mother of the bride was consulted and she had a voice in the selection of a son-in-law.[3] Kautukamaṅgala was a pre-nuptial rite of tying a piece of thread on the wrist, and it was performed on an auspicious day.[4] Particular herbs were entwined in a garland (Kautukamālā) worn by the bride. The actual marriage ceremony was performed with all the pomp of decorations, ornaments and foods.[5] Female relations of the bride used to receive the bridegroom, who came in a specially fashioned car.[6] Possibly the widows were excluded from the marriage ceremony.[7] *Gāndharva* was love marriage with consent, prevalent among the Kṣatriyas. In Bhāsa's time, religious rites were thought necessary to perfect the *Gāndharva* (and Rākṣasa) marriages.[8]

The marriage of Avimāraka is important to us from the fact of its disregarding the rule of consanguinity or sapiṇḍa exogamy. In Vedic times marriages with cognatic relations to the third degree were recognised.[9] Jātakas also tell of the non-observance of the rule of consanguinity.[10] Gradually, the smṛti writers increased the number of the prohibited degrees.[11] It will be seen that Avimāraka is marrying his maternal uncle's daughter, who was at the same time his paternal aunt's daughter (i. e. third degree).[12]

1. विवाहा नाम बहुशः परीक्ष्य कर्तव्या भवन्ति । Av. p. 3; Pry. II. 4.
2. Pry. II. 4; also. Av. I. 3.
3. Pry. pp. 28 29. Av. p. 38. तर्हि किळ etc. Kuraṅgi's marriage post poned.
4. सोभणं णक्खत्तं । Sv. p. 49.
5. Sv. Act. IV. प्रवेशक.
6. जामातरं प्रवहणादिव बन्धुनार्यः । U. 9.
7. Sv. p. 57. अविहवाहि.
8. Cf. 'अग्निसाक्षिक' Av. p. 103. 'क्षत्रधर्मेणोद्दिष्टः' Pry. p. 72. 'अणग्गिसक्खिअं etc.' Sv. p. 133.
9. Hindu Exogamy p. 14.
10. Cf. I. 126; II. 193.
11. Maternal relations to the third, fifth and seventh degrees, and paternal relations to the fifth, seventh degrees.
12. दुर्योधन

कुन्तिभोज — Queen, sister of सौवीरराज. — कुरङ्गी, सुमित्रा

सुदर्शना — Married काशिराज. — जयवर्मा

सुचेतना — Married सौवीरराज brother of the queen of कुन्तिभोज — अविमारक.

Marriages of Cārudatta and Sajjalaka (both Brāhmaṇas) with Vasantasenā and Madanikā suggest *Anuloma* marriage or hypergamy. It is not stated whether any ceremonies were performed.

It is contended[1] on the strength of the stray use of the word "Sambandha," whieh is not used in its technical sense, in some of the plays that the *Sambandha marriages* are referred to. "Sambandha is . . . . . civil marriage with right of divorce. The presentation of cloth by the vara to the vadhū with a social dinner constitutes the entire ritual. No Sanskrit mantras are recited . . . . the wife does not share the religious life of her husband and the husband does not interdine with his wife."[2] Applying these tests to the marriages of Vāsavadattā and Kuraṅgī which are alleged to be Sambandha marriages, we find that neither can be styled as such since both parties belonged to the same caste, religious ceremonies were performed, and there was no idea of divorce.

It seems there were no child marriages. Polygamy was then as it is even now, a fashion among the kings and the rich. Monogamy seems to be prevalent among the commoners.[3]

The wife thought it her prime duty to follow her lord,[4] sacrificing her likes and dislikes for him.[5] It was thought improper for women to see a stranger or hear his praise.[6] The husband also avoided the sight of other women.[7] There is no reference to remarriage in any of the plays, so far as we could see.

6. Position of Women: The period under our review is characterised by the spirit of toleration towards women. The birth of a female child was an occasion of joy.[8] The *maidens* enjoyed perfect freedom; arrangements were made for teaching music, singing and dancing to them.[9] The then prevalent purdah system was not enforced in the case of maidens. They moved unveiled in their palanquins[10] and the sight of a maiden was thought free from taint.[11] Unmarried girls used to play the game of ball and similar games in the company of their companions.[12] Position of *married*

1. S. K. Sastri, Āscarya, intr; K. R. Pisharoti, Shama'a, 6.
2. K. G. Sankar's letter dated 14-8-32.
3. Cf. Jātaka IV., 489.
4. भर्तृनाथा हि नार्यः । Prat. I. 25.
5. Cf. Vāsavadattā; Dhūtā (Cār. pp. 81-82).
6. अजुत्तं परपुरुससंकित्तणं सोदुं । Sv. p. 55.
7. अये स्त्रीजनः । Sv. p. 26; also p. 136. Av. p. 10.
8. Av. I. 9. cf. Av. I. 2.
9. Pry. Act. II. उत्तरावैतालिका, Pañc. बृहन्नला.
10. अवणदिकञ्चुकाए सिविआए । Pry. p. 50.
11. कण्णआदंसणं णिद्दोसं । Pry, p. 50.
12. Sv. Act. II.

women has been already considered.[1] *Widows* dressed differently from married women whose husbands were living,[2] and did not use ornaments and toilet.[3] Women separated from their husbands for the time being, did not put colyrium in their eyes, nor combed their hair.[4] They used to braid their hair in one plait.[5]

No barrier was placed in the way of women embracing *asceticism.*[6]

There was a system analogous to the present purdah,[7] the whole face including the head being veiled. Even courtesans were veiled[8] when passing in carriages.[9] The purdah was done away with on specific occasions.[10]

A stray instance[11] of a wife desiring to follow her husband to the funeral pyre cannot sufficiently warrant the inference of the prevalence or otherwise of the system of Satī. There is also a single instance of a woman knowing reading and writing.[12]

7. *Urban and Rural Life:* We have a fine and realistic description of a city in the evening.[13] There were palatial buildings in the business quarters of the city, and the verandahs on the ground floor were employed for selling country sugar, honey etc. The fashionable city-bred beaus and courtesans vied with each other to show themselves in their best, and were to be seen walking to and fro in the balconies of their respective quarters.

There were beatings of drum and proclamation[14] to mark the beginning and close of the night, to warn the residents against moving during the period; but the injunction was not strictly followed. Nightguards and watchmen used to patrol the streets.[15]

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1. Cf. also हृदयार्धेन मे । Prat. I. 10.
2. अज्जआळिअं च दे वेसग्गहणं अहं वि उवधारइस्सामि । Dg. p. 52.
3. Av. p. 54. ... ... सद्दाळङ्किदा भट्टिदारिआ होदु ।
4. Sv. V. 10. नेत्रविप्रोषिताञ्जनम् and दीर्घालकम्.
5. Abh. II. 8. एकवेणीम्. Women in their husbands' company used three plaits.
6. Contra Smṛti writers.
7. Prat. p. 36. अपनीयतामवगुण्ठनम् । Sv. p. 140. संक्षिप्यतां यवनिका ।
8. U. 38. प्रकाशीकृतमूर्धजानि ।
9. Cār. p. 89. गहीदावगुण्ठणा ।
10. Prat. I. 29. यज्ञे विवाहे व्यसने वने च ।
11. U. p. 109. एक्कफिदप्पवेसणिच्चआ ।
12. Pry. pp. 3-4. राजमाता.
13. Av. Act. II. pp. 27-28.
14. Cār. p. 65; 78. cf. Arth. II. 57. p. 146. विषण्णाळिकमुभयतो रात्रं यामतूर्यं ।
15. Av. p. 45. अये रक्षिणः खल्वेते ।

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In spite of these precautions, thieves were not uncommon, as also the bravadoes with their servants, following nefarious practices.[1]

At night, the city was completely engulfed in darkness save what little light came from the windows of the buildings on both sides of the street.[2] Possibly there were no lamp posts, and no arrangements for lighting the streets. Singing and music conferences went on till late at night; respectable persons felt no hesitation in attending them.[3] Some persons enjoyed song and music in their own houses.[4] The courtesans followed their trade in the business quarters,[5] their residences being outside the cities.[6] The gaming houses were situated at prominent places.[7] A tavern keeper selling liquor is mentioned only once.[8]

There were undergroud drains to take away water outside the cities.[9] The cities were fortified.[10] There were well-watered green trees and blossoming gardens just near the cities,[11] private and public parks and pleasure-gardens being in the cities themselves.[12] Citizens with their wives went there for merry-making, as also the persons from royal families.[13]

Residential quarters: Not much is said about these in the plays. The houses of persons of the upper middle class were built of bricks and were surrounded by gardens.[14] There were quadrangular court yards inside the house, and inner still were the quarters for the women folk. There seem to have been separate apartments for the maidservants.[15] There is no mention of any furniture in the house. Cāṇḍālas had to reside outside the cities.[16]

An ideal thoroughbred gentleman of the town was kind to the servants, ready to appreciate and reward good works.[17]

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1. Cār. Act. I. Av. p. 45 'तस्करः'.
2. Av. p. 45, नैषा जोत्स्ना etc.
3. Cār. pp. 64-66.
4. Av. pp. 43-44.
5. Av. p. 44. नगरापणालिन्दे । also III. 8.
6. Av. p. 29. अळद्धभोआ पाअडगणिआ etc.
7. Av. p. 45. शृङ्गाटकस्थां विटसभां ।
8. Pry. pp. 56-58 Contra—Jātakas.
9. Pry. p. 50. ओघट्टिदपणाळीपस्सुदसळिळविसमं राअमग्गं । cf. Arth. II. 65. p. 167. पणाळीमोक्षो वर्षति ।
10. Pry. p. 64. 'प्राकार.'
11. Prat. p. 57; Abh. p. 6.
12. Cār. p. 73; Av. p. 2.
13. Av. p. 2.
14. Cār. p. 73; Act. I.; III. 8. also Av. pp. 10, 23.
15. Cār. p. 81.
16. Av. p. 14; Pañc. p. 52.
17. cf. Cār. pp. 51-53; 60-61.

Some idea of pastoral life is conveyed by the cowherds in the Pañc and B.[1] On festive occasions they made ready for fun and dance, in which youngsters of both sexes participated. They were susceptible to common superstitions. Cows were like goddesses to them. Sometimes they resided in the suburbs, and their dwelling places seem to be quite humble, though to them they were quite समृद्ध.

8 Court Life: We get a description of the place of a king in Av and Abh.[2] It was fortified on all sides by strong and high walls, which had roads on them from inside, and kapi-śīrṣakas were placed at different points. Gajaśālās, guest houses, artifical lakes, pleasure-mountains, coolrooms, music halls, theatre,—formed part of the palace.[3] The residence of the princesses was a specially guarded part known as Kanyāpuraprāsāda, having much wood work and ornament. It had many mechanical entrances and exits.[4] The princesses had their own establishments and exclusive pleasure gardens (प्रमदवन).[5] The palace was always a hot-bed of various plots and counter-plots and anything was thought probable to happen within its four walls.[6] It had an armoury, where royal prisoners were kept.[7]

The kingship was not conferred by election but was hereditary.[8] The hour of the day was announced to the king, and at ten nāḍikās from sunrise and sunset the king had baths.[9] The king was generally conscious of his high responsibilities.[10] The principles of administration are given in Av I. 12.[11] The king was enjoined upon not to spare himself on the battlefield.[12] Political marriages show influence of politics on the kings. In short, care of the subjects and their protection was the prime concern of the king.[13] He used to collect one-sixth of the produce as tax.[14]

1. Pañc. Act. II. B. Act. III.
2. Av. Act. III. pp. 46-47. Abh. II. 2.
3. cf. also Sv. Act. IV; Prat. p. 8.
4. Av. pp. 47-48. 'काष्ठकर्मबहुलतया' p. 47. 'जालयन्त्र' p. 48.
5. Sv. Acts II, IV.
6. Prat. p. 15. बहुवुत्तन्ताणि राअउळाणि णाम ।
7. Pry. Act. II; p. 67. For the whole description of palace. cf. Arth. I. 20. II. 25.
8. Majumdar, Corporate Life, 97, 101, 110. cf. Pry. सहस्रानीक–शतानीक–उदयन, Av. दुर्योधन–कुन्तिभोज; काशिराज–जयवर्मा; सौवीरराज–अविमारक. cf. Arth. V. 96. pp. 254-257.
9. Abh. p. 28; Av. pp. 13, 32. cf. Arth. I. 7. p. 13.
10. Av. p. 13. अहो महद्भारो राज्यं नाम ।
11. cf. Arth I. 4. p. 9. तीक्ष्णदण्डो हि etc.
12. Av. I. 12 d. also Pañc. II. 5.
13. K. 17. तस्मात्प्रजापालनमात्रबुद्ध्या... । cf. Arth. I. 19. p. 39. प्रजासुखे सुखं राज्ञः ।
14. Av. p. 62. षड्भागग्रहणमस्माकं धर्मः ।

Elaborate were the preparations that were made at the coronation of a new king, in which the citizens also took part.[1] The whole ceremony was a religious affair and a dramatic entertainment marked its close.[2] The advent of a new king was looked upon with great suspicion and anxiety by the subjects.[3]

The kings do not seem to have had a large retinue—only the female doorkeeper, an attendant and the jester companion are met with.[4] Female torchbearers are mentioned only once.[5]

Ministers occupied high position with the king, being consulted even as to the selection of a suitable match for the princess.[6] They were ready to die for their king, his uplift being their constant concern.[7] They wielded a considerable influence with regard to foreign policy. Messengers or emissaries of peace were sent to the enemy and they did their work in spite of danger to their lives.[8] Messengers, however, were not to be killed.

The secret service department was efficiently managed and information was obtained about the king's subjects and foreigners.[9] The spies went under the guise of madmen, mendicants etc., held conferences in lonely places and tried to achieve their objects by bribing the servants of the enemy or by getting their men employed in the services of the enemy.[10] Vatsarāja was captured and freed through the secret service.[10] Spies were called "eyes" of the kings.[11] No details about the machinery of administration so elaborately given by Kauṭilya are found in our plays.

9. War.

There were four divisions of the army—elephants, chariots, horsemen and infantry. *Elephants* constituted the principal factor of army in ancient India. A deep blue elephant with certain characteristics was reputed to bring sovereignty to its owner king.[12] There were spacious stables, and a number of attendants for the

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1. Prat. I. 3.
2. Prat. p. 8. काळसंवादिणा णाडएण etc.
3. Prat. I. 14.
4. Contra Arth. I. 21. p. 42.
5. B. II. 2. दीपकधराः प्रमदाः ।
6. Abh. p. 7. अमच्चवग्गेण सह संमन्तिअ गन्तव्वम् । also Pry. and Av.
7. यौगन्धरायण, रुमण्वान् and भरतरोहक in Pry.; and the former two in Sv.
8. घटोत्कच in Dgh. (pp. 66, 67). हनूमान् in Abh. (pp. 41-42). वासुदेव in Dv. cf. शासनं च यथोक्तं ब्रूयात् प्राणबाधेऽपि दृष्टि । Arth. I. 16. p. 30.
9. Av. I. 12 c.
10. cf. Pry.
11. Av. I. 12. परचरनयनैः ; p. 99. सहस्रनेत्रः for espionage cf. Arth. I. 11-14; II. 56; IV. 81-84.
12. Pry. p. 9.

elephants. Various methods of charming and capturing elephants were given in the Hastiśikṣā.[1] The elephant for war wore an armour,[2] presumably over its trunk. *Chariots.* Each warrior (रथि) had his particular driver expert in driving and turning the chariot in various ways.[3] *Horses* from Kāmboja were regarded as the best.[4] The science of keeping and tending the horses was developed and they were worshipped on particular days.[5] Various *weapons* and implements of war are mentioned by our poet and nearly all of them are found in the Arthaśāstra.[6] करवाल and शङ्कु are not found in the Arth.; but the former seems to be a sword. The arrows had on them engraved the names of the warriors to whose quiver they belonged.[7]

Before the war, each member of the army was carefully scrutinised. The inspection was conducted by asking each commander about the soldiers under his charge; and such enquiry was facilitated by the army register, specially prepared for the particular war containing the name and descriptive particulars of each soldier.[8] During the war the various war songs, glorifying death on the battlefield, were sung to encourage the soldiers.[9] After the war, the principal duty of the commander-in-chief was to reward the brave according to their merit. The names of the warriors were recorded in the "Annals." The head of the defeated army, however, took it as his main concern to enquire as to the safety and whereabouts of the officers under him.[10]

10. Fine Arts.

Sculpture seems to have attained a very high degree of perfection. Statues of dead kings used to be carved of stone or granite. They bore remarkable likeness to the original and wore human expressions.[11] Some peculiar characteristics of the individual kings were shown by symbolic marks.[12] Probably offerings of food were

1. Pry. p. 9.
2. Ū. 8.
3. cf. विराट, उत्तर and अभिमन्यु in Pañc.
4. K. 19. Arth. II, 51. p. 133.
5. Pry. I. 12. Arth. II. 51. p. 135.
6. Following the divisions of the Arth. (II. 39 pp. 101-102) the weapons may be classified as: (i) चल–मुसल, मुद्गर, गदा, त्रिशूल, चक्र. (ii) आयुध—शक्ति, प्रास, कुन्त, हाटक, किण्डिपाल, शूल, तोमर, वराहकर्ण, कणय, कर्पण, त्रासिक. (iii) बाण—नाराच, शर. The weapons are mentioned in Ū, Pañc, Pry. etc.
7. Pañc. II. 50; III. 17.
8. Abh. pp. 54-56.
9. Pry. IV. 3. Arth. X. 131. p. 368.
10. Pañc. p. 70; II. 28; p. 91. also pp. 100-03. cf. Arth. X. 131.
11. Prat. p. 59. अहो क्रियामाधुर्यं पाषाणानाम् । अहो भावगतिराकृतीनाम् ।
12. Prat. p. 62. H. Sastri, Prabuddha Bhārata, 1929, 131; Pisharoti, Quarterly Jnl. Mythic Soc., 12, 388-89.

made occasionally. These statues were kept in the *Statue-houses*, which outwardly resembled the temples. They were tall and magnificent structures, erected just outside the cities.[1] A priest, an attendant and a servant were attached to the statuehouses for daily services and the upkeep.[2] They were looked upon as shrines and were free to everybody.[3] Special preparations made on the visit of the royal family are elaborately given.[4]

Painting : Many are the references to painting and there are some significant similes describing pictures on a canvas.[5] The details about the portraits show that the pictures caught much of the likeness of the object.[6] Only one *musical instrument* is mentioned *i. e.*, lute. The lutes of rich persons were stringed with wires of gold.[7] The art of weaving shows a developed phase, in that the garments made from barks of trees were not easily distinguishable from those of cotton, ordinarily used.[8]

11. Religion, Philosophy, Literature and Sciences :

Hinduism : Idol worship was in a developed stage, there being temples[9] dedicated to various deities. In a prominent place on the temple, so as to be visible from a distance, were placed the symbols or weapons of the particular deity that was enshrined.[10] Some temples had festivities on the full moon day while some had them daily.[11] It was not rare to find more than one idol in a temple.[12] The following deities from the Hindu pantheon were specially worshipped: Viṣṇu, Śiva, Kārtyāyanī, Skanda etc. Rāma and Kṛṣṇa were looked upon as incarnations of Viṣṇu ; still, there were some who denied divinity to Kṛṣṇa and lightly called him a "cowherd."[13] There were temples dedicated to Yakṣiṇīs, and maidens used to worship them on the Aṣṭamī.[14] Curiously enough, we find belief in a half-male half-female godhead—the Ardhanārīśvara form of Śiva. (Av II. 12 d).

1. Prat. p. 58 ; III. 13.
2. cf. देवकुलिक, भट and सुधाकार in Prat.
3. Prat. III. 13.
4. Prat. Act. III. pp. 54, 59.
5. cf. सङ्कीर्णलेख्यमिव चित्रपटं... । ū. 3.
6. Dv. pp. 9-12 ; Sv. pp. 134-36 ; Cār. p. 88.
7. कञ्चणमाळं वीणाजोग्गं करअन्ति... । Pry. p. 28.
8. Prat. I. 9. ... वल्कलानीव किमेते सूर्यरश्मयः ।
9. Pry. p. 49. 'देवकुल'.
10. Prat. p. 59. ध्वजः प्रहरणो वा ।
11. Prat. p. 59. पार्वणो...विशेषः अथवा आह्निकम्... ।
12. Prat. p. 59. चतुर्दवतोऽयं स्तोमः ।
13. Dv. p. 7. स गोपालकस्तव पुरुषोत्तमः । p. 26. कथं कथं गोपालक इति ।
14. Pry. p. 51.

Sacrifices were much in vogue; the merit one got by their performance, was thought to be everlasting.[1]

Buddhism, though trying to gain ground, does not seem to have got a stronghold at the period. The Buddhist mendicants were lightly spoken of as conjurers.[2] The Buddhist laymen were also ridiculed as unmattopāsakas;[3] and the morality of the Bhikṣus was thought to be questionable.[4]

Jainism was equally regarded with deprecation,[5] and the other sect seems not to have been promulgated till then. Both these religious systems were looked upon as heretical.[6]

Philosophy: The Pāñcarātra system of philosophy seems to have had followers. Kṛṣṇa was worshipped under different names of Vāsudeva, Saṅkarṣaṇa, etc. Vedas and sacrifices were accepted as conducing to spiritual welfare. The system is also known as Sātvata Bhāgavatism.[7]

The theory of rebirth was acceptable[8] and the learned comparisons about the five senses leaving the body through the holes,[9] show rather a developed taste at hairsplitting.

Languages and Literature. Sanskrit was the spoken language of the literate cultured class and Prakrit was that of the women and the low people. Both were in their stages of development, and were not merely 'literary languages.' In addition to the various works of antiquity mentioned in the Prat., Hastiśikṣā was well known, as also a treatise on dramaturgy.[10] The Mahābhārata, Bhagavadgītā and Rāmāyaṇa were quite known to all.

Astronomy and Astrology. If the reading preferred by Prof. Bhide[11] is accepted, it would seem that there was an observatory at Ujjain. Tithis and nakṣatras only were known, the forecasts being based on the nakṣatras (Rohiṇī, Kṛttikā).[12] The moon was known to be the cause of the tides.[13]

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1. K. 17. हुतं च दत्तं च तथैव तिष्ठति ।
2. Pry. pp. 45-46. पेक्खं पेक्ख ममप्पभावं ।
3. Pry. pp. 44, 45.
4. Cār p. 74. कत्तव्वकरत्थीकिदसद्दो विअ सक्किअसमणओ... ।
5. cf. Av. p. 72. किण्णु खु जीवादि णग्गन्धस्समणिआ ।
6. Av. p. 15. ' अवेदिओ.' cf. Arth. III. 77. p. 199. शाक्याजीवकादीन् etc.
7. cf. Mbh. Sāntiparvan, Adh, 334-351. The maṅgalaślokas in our plays, mention of Balarāma in a maṅgalaśloka, personification of the weapons (Dv. B) and the very name Pañcarātra for a play—show the influence of this system.
8. U. 50. अन्यस्यामपि जात्यां... (p. 108).
9. Pañc. I. 10.
10. Prat. p. 99; Pry. p. 9; Av. p. 16.
11. p. 33 of Bhide's edn.—Notes.
12. Prat. p. 58.
13. Abh. VI. 2 ed.

Medicine: Various herbs were known. Cāṅgerikā was reputed to bring coolness to the head. Other cooling herbs were also locally applied, giving instantaneous relief.[1] The psychological aspect of diseases was not lost sight of, and the sickroom was well decorated to divert the attention of the patient.[2]

12. Social manners and Customs:

i. Food, Drink and Dress: Among the edibles mentioned, there is only one article from the non-vegetarian menu, *viz.*, piece of mutton saturated with salt, ghee etc.[3] The other delicacies mentioned are: मोदक (Pry III) घिदं, गुळं, दाहिं, तण्डुला (Cār p. 4). Condiments (हिंगु-Cār. p. 9) of different kinds were used to flavour the dishes. The similes of the gluttonous jester do not cover the non-vegetarian field. Hence it seems that the diet was mainly vegetarian,[4] and the lower castes used meat. We get only one reference to *drinking*,[5] *viz.*, in a public tavern; so the statement of Megasthenes[6] that wine was rarely drunk seems to be correct. *Dress.* Two pieces of cloth were used, one as a lower garment, and the other as an upper one (uttarīya).[7] Possibly yajñopavīta was a piece of cloth in those days and was not made of thread.[8] No particulars as to the dress of women are given, but it would seem that they wore two clothes.[9] Sprouts of talī tree were used to grace the ear.[10] Ornaments were worn on the hands and the ears.[11]

ii. Sports and Festivities. There were a number of public festivities in which all took part. Kāmadeva mahotsava seems to have been specially favoured by the young persons of both sexes.[12] Indramaha and Dhanurmaha were other festivals, a sort of olympic games being arranged in the latter.[13] Wrestling was more popular

1. Av. pp. 80-81. अज्ज विअद्दोआ सोत्था होदित्ति । (p. 81).
2. Sv. V. 4. c.
3. Pry. p. 57.
4. Contra-Jātakas speaking of Brahmin flesh-eaters: I. 18, 30, 142; IV. 495, etc.
5. Pry. Act. IV. प्रवेशक. That the servant was not really drunk but was feigning to be under the influence of liquor would be seen from his recourse to Sanskrit and saying: आः को मत्तः, कस्य वा मद: etc. । Pry. p. 62.
6. Cam. Hist. Anc. India, 1, 412-413. cf. Also Arth. II. 46. pp. 119-121.
7. Prat. I. 31a. It seems dresses in different provinces were distinct. Prat. III. 3. वेषं च.
8. Cār. p. 63. Also, Jha, Asutosh Mem. Vol, I, 60-63.
9. Av. p. 82. उत्तरीअवासेण.
10. Cār. p. 82.
11. Prat. I. 8.
12. Cār. Acts. I, II.
13. B. act. IV. p. 55; Act. V.

and even princes were fond of it.[1] The king used to be present in the special arena prepared for the wrestling bouts. Fights of unarmoured persons with the elephants were also common.[2]

iii. Conveyances: Chariots, palanquins, carts and carriages, horses, and elephants were the means of conveyance. Chariots, used to be drawn by horses or donkeys,[3] though the latter were also employed as beasts of burden.[4] There were different carriages for different occasions. Gentlemen used covered carts (pravahaṇas) or yānas. The carriages for marriage ceremonies were known as Vadhūyānas. Puṣyaratha was used for coronation. Horses used to be ridden for long journeys.[5] Carts were drawn by bullocks also, and the latter were used as beasts of burden. There is no reference to the condition of the roads, nor to the maritime trade, navigation, etc., though a ship is indicated in a couple of similes.[6]

iv. Popular beliefs, Superstitions, etc. Belief in 'magic,' by which one could change one's countenance or disappear, etc.,[7] is found to be prevalent. Some mantras were believed to render the occupants of particular residences drowsy.[8] A crow sitting on a dry tree facing the sun was taken to bring disaster.[9]

v. Trade and Industry: The poet does not furnish us with any information as to the internal or foreign trade.[10] Jewellers, goldsmiths, ironsmiths, shampooers and garland-makers are mentioned among those carrying on trade of some kind or the other. Long journeys for commercial purposes, group of merchants travelling together and roads infested with thieves may be inferred.[11]

Weights and Measures: There is possibly no reference to weights in these plays. Dhanu, Krośa, yojana—are mentioned as measures of distance.[12] As to measures of time, Nāḍikā, Divasa and Varṣa are mentioned.[13] *Coins.* Suvarṇa and Māṣaka are mentioned as coins.[14] Suvarṇa was a particular weight, but the

1. Prat. II. 13. ed.
2. cf. B. and Av.
3. Pry. p. 32. 'खररथेन'.
4. Cār. p. 70. भरिदूगद्दभो विअ.
5. Pry. Act. I. Vatsarāja.
6. Cār. p. 39. विवहन्ता इव सअडिअं दुव्विणीदबळीवद्दा ।
7. Pry. and Av.
8. Av. p. 46; Cār. p. 75. cf. Arth. XIV. 148. pp. 418-425. esp. p. 419.
9. Pañc. p. 48.
10. cf. Jātakas. I. 4, 41; II. 186, 190; III. 339.
11. Cār. p. 77. भीदीए उप्पहप्पवुत्तो; p. 45. वणिजदारओ आअन्तुओ; also p. 78.
12. Pry. pp. 11, 8 (9), 8. cf. Arth. II. 41. pp. 106-07.
13. Abh. II, Av. II, Prat. V.
14. Cār. p. 55, Dv. p. 9; Cār. pp. 7, 9, Pry. p. 46.

term denoted the gold and silver coins of the same weight.[1] There were Māṣas of copper, silver and gold.[2] A *deposit* was required to be passed over to the bailor in the presence of a witness.[3] Taking up loans on the security or *mortgage* of the moveables was known, as also *interest* on the principal advanced.[4]

vi. Slavery:[5] There were male as well as female slaves. They could gain freedom on the payment of some ransom to their master and again be included among the Aryans. Those that deceived their masters were again condemned to servitude.[6]

vii. Public Vices: Gambling, theft and prostitution[7] seem to be present to some extent. There were rules and regulations of the gaming table. Thievery was practised as an art, the thief proceeding to his work after invoking blessings of the patron deities, with all his paraphernalia of house-breaking outfit, measuring thread, bee etc. The courtesans were cultured and expert at music, painting and dance.[8]

viii. Manners: Honour and respect were always paid to the elders, mere mention of the name of a venerable person was revered by the listener by getting up from his seat.[9] The guest was honoured with the traditional Indian hospitality and feeding a guest was taken equivalent to performing a sacrifice.[10] Some Jātaka stories countenance the assumption of the absence of the joint family system, but there is nothing in the plays either in support or against that assumption, Tālīpatra was the writing material used in the north.[11] It is interesting to note that out of the various modes of ending life, that by drowning oneself was condemned. Entering the fire or throwing oneself down off the precipice seems to have been

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1. Ind. Hist. Quart. 1929, 693.
2. cf. Arth. I. 40, p. 103; I. 33. p. 84.
3. Sv. p. 139. साक्षिमन्न्यासो निर्यातयितव्यः ।
4. Pry. p. 59. 'आदत्त' p. 61. 'मूळविद्धि'.
5. cf. Arth. III. 70. pp. 180-183.
6. Cār. p. 91. विक्कएण मां याचेदि । also p. 92, p. 102. अय्या खु सि दाणिं संवुत्ता । cf. Arth. मूल्येन चार्यत्वं गच्छेत् p. 182. Cār. p. 96. अज्जुअं च पुणो वञ्चिअ पुणो एव्व दासभावो भवे ।
7. Cār. p. 55, Av. p. 45; Cār. Act. III, Av. p. 45; Cārudatta and Sajjalaka in Cār.
8. Cār. pp. 75, 77 etc. Vasantasenā and Madanikā in Cār.
9. उदयन at the mention of महासेन (Sv. p. 129): विराट at the mention of भीष्म (Pañc. p. 60) धृतराष्ट्र at the mention of...नारायण (Dgh. p. 65).
10. Av. p 87. इट्ठं आअन्तुअस्स भोअणदाणं ।
11. cf. Arth. II. 38. p. 100. ताळीताळभूर्जानां पत्रम् ।

the approved form of committing suicide.[1] As to the disposal of the dead we have a clear indication to the funeral pyre and the burning of the corpses.[2] The spirit pervading every one of the plays voices forth the craving and the liking of the general populace for freedom and good government.

A. D. PUSALKER

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॥ तत्सद्ब्रह्मार्पणमस्तु ॥

1. Av. pp. 59, 60. Perhaps the poet was referring with approval to the mode of killing themselves employed by Udayana Vatsarāja and his Queens. They ascended the top of a precipitous hill and killed themselves by falling from the precipice.—Dr. Pradhan, *Chronology of Ancient India*, p. 246.

2. Dgh. 9, चितां न तावत् स्वयमस्य देहमारोपयन्त्यर्जुन दर्शनार्थम् । (p. 55).

THE REGISTRATION OF FIRMS

Until the Indian Partnership Act was passed in 1932 there was no provision of Indian Statute Law which required the registration of firms in British India. That Act, for the first time introduced a new feature into the Indian Law of Partnership by providing a machinery for registration which may or may not be availed of by firms doing business in British India, at their option, but which they are obliged to have recourse to, if they wish to enforce certain legal rights through a Court of Law. It cannot be said that the Chapter relating to the registration of firms is really an integral part of partnership law. In fact, the English Partnership Act, 1890, does not contain any provision for the registration of firms in the United Kingdom, although there is a separate enactment which requires firms carrying on business under a name, not consisting of the true surnames of all partners who are individuals and the corporate names of all partners who are corporations, to be registered in the manner provided. (See the Registration of Business Names Act, 1916). Whether we regard the Chapter on Registration as part and parcel of the law of partnership, or as supplemental to it, no one can deny that it has brought about a change in the law which is of considerable importance to traders, merchants and professional men doing business in partnership.

The idea of registering firms is not a new one. As far back as in the year 1867, the Bombay Chamber of Commerce came forward with a suggestion that legislation should be undertaken for the compulsory registration of firms in India. The suggestion was not taken up, probably because it was thought that the country was not yet ripe for such legislation. Since then, several mercantile associations, mostly foreign, repeatedly urged the need of such legislation upon Government. The passing of the Registration of Business Names Act, 1916, in England lent support to the demand for legislation on similar lines in India. The Industrial Commission, in 1918, and the Civil Justice Committee, in 1925, recommended a system of compulsory registration. In the meantime, the Burmese Legislature had passed the Burma Registration of Business Names Act, in 1920, whereby the principle of compulsory registration was applied to certain towns in Burma. The Government of India, however, showed some hesitation in undertaking legislation in this

direction, partly because there was considerable divergence of opinion on the wisdom of such a step, and partly because there were certain inherent difficulties in the subject-matter of the proposed legislation. These difficulties were peculiar to the existing conditions of trade and business in India, and arose with reference to family business carried on by Hindu undivided families, short-lived partnerships and firms in a small way of business. They have been discussed in detail in the Report of the Special Committee on the Indian Partnership Bill, in paragraphs 14 to 16, and, it would be enough for the purpose of the present discussion to give only a brief summary of them here.

It is well known that there is a large number of Hindu undivided families in India which carry on what are known as family businesses. The benefits of such businesses may be either restricted to the families themselves, or may be shared with them by outsiders as partners with them. It would be impracticable and inconvenient to require that each member of a Hindu undivided family carrying on a family business should have his name registered, because every birth or death of a male child and every partition in the family would necessitate a change in the register. Further, the mutual relations and liabilities of the members of such a family are governed by the Hindu Law and not by the law of partnership. Where a joint Hindu trading family enters into partnership with an outsider, the names of its members need not be registered, because the partnership relation which is contractual exists only between that member of the family who makes the contract of partnership and the outsider. The question whether the interests of the other members in the joint family property are liable to be proceeded against for the debts of the firm depends on mixed questions of fact and law, the law being not that of partnership, but the Hindu law.

The difficulties with regard to the registration of short-lived partnerships and firms in a small way of business are of a somewhat different kind. If the Legislature were to insist on every small and ephemeral partnership venture being registered, petty enterprises would be considerably hindered, while no substantial benefit would accrue to the public. To overcome this objection, it was suggested by those who advocated compulsory registration that firms with a capital below a fixed minimum should be exempted from registration or, in the alternative, that suits below a certain value should be exempted from the operation of any legal provision imposing disabilities on unregistered firms. The suggested remedy had, however, its own drawbacks, for the capital of a firm fluctuates from time to time, and cannot be ascertained without detailed calculations, and the valuation of suits is liable to be made in a way that is likely to achieve the object of a dishonest plaintiff.

The passage of the Indian Partnership Act through the Indian Legislature was not entirely smooth. Although no objection was taken to the Act as a whole, in so far as it attempted to consolidate and amend the previously existing law of partnership, the introduction of the new principle of registration evoked a storm of criticism both from mercantile associations and from members of the Legislative Assembly, which would have wrecked the Bill, but for the skill with which it was piloted by the Law Member.

As was pointed out by Diwan Bahadur Harbilas Sarda in the course of the debate on the Bill in the Legislative Assembly, the opinion of the Indian business community was almost unanimously opposed to the enactment of the Chapter on registration. A few relevant extracts from the opinions of some of the Indian Traders' Associations consulted by Government may be quoted as examples of the arguments advanced by the Indian Mercantile community as a whole.

The Indian Merchants' Chamber, Bombay said :—

> "In the opinion of the Indian Merchants' Chamber, having regard to the conditions prevailing in India, and to the fact that capitalists are shy to invest their monies in adventures, such a provision would be detrimental to the interests of the commercial community as a whole, and would prevent capitalists from coming forward to help small firms in their adventures......"

The Bombay Piece-Goods Native Association, after pointing out that it was remarkable that the desire for making the registration of firms compulsory had emanated only from European Chambers of Commerce in India, and that no recognised Chamber of Commerce of Indian Merchants, individual or Trade Association had ever approached Government with a similar request, added :—

> "My committee feel that Government are surely not unaware of the hardships to which the small trading firms are likely to be put. Most of them do business in a small way, and are quite ignorant of the complicated machinery of registration. The result will be that, in spite of very elaborate organisation, many of the firms will remain unregistered to the great detriment of the partners who will run the risk of unknowingly losing their money....... In this connection, my committee have noticed that though the Special Committee on the Bill were aware of all these difficulties, they have tried to pass over them by imagining that Registration is only optional. As a matter of fact, the penalties imposed are so heavy that it is straining the language too far to say that the provisions are merely optional ...."

The Grain Merchants' Association, Bombay, remarked:—

> "Although the registration is stated to be optional, the dis-

abilities arising out of non-registration are such as to make registration almost compulsory...... My Committee suggest that the Chapter on registration should be entirely dropped from the Bill."

The Marwari Chamber of Commerce, Bombay, referring to the Chapter on Registration, said :—

"This is a very radical and sweeping change from the existing position...... If this clause is not cut out, serious harm will be caused to Indian trade and commerce. In rural areas throughout the country there are innumerable little partnerships formed for small ventures or undertakings from time to time in the course of the year, and particularly during the movement of crops. It is simply absurd to suggest that the illiterate simple-minded folk who enter into these partnerships should go through the troublesome process of registration and conform to the elaborate rules of intimating changes in their firms, places of business, etc...... Besides, such a sweeping change cannot be justified except on the ground of a general and widespread dissatisfaction with existing conditions. My Board are not aware of any general complaint in respect of disclosure of composition of partnerships. In view of this my Board strongly recommend that clause 68 should be deleted."

The opinions quoted above are a fair sample of the view taken by the Indian business community.

On the other hand, a large part of the British mercantile community in India, not only gave its whole-hearted support to the Bill, but was anxious that registration should be made compulsory as in England, where a firm is prevented from bringing an action in respect of a cause of action which arose before it was registered. It was also urged on behalf of this section of the trading community that Hindu undivided families carrying on family businesses should be required to register in the same way as ordinary partnerships.

The framers of the Indian Partnership Act fully realized the difficulties which stood in the way of bringing Hindu undivided family concerns under the operation of any provisions they might lay down in the Act for the registration of firms. They wisely confined their attention to ordinary partnership firms which are contractual in their origin. It was also considered that by making registration optional, and offering substantial inducements to register, all the benefits of the system of registration would be achieved without introducing the unwelcome feature of compulsion. While, therefore, the corresponding English enactment makes registration compulsory, and imposes a penalty for non-registration, the Indian Act does not make it obligatory on firms to register under penalty of a fine, but merely prevents an unregistered firm from enforcing

its claims against third parties in the Civil Courts, and partners in such a firm from enforcing their rights against their co-partners, except with regard to a claim for dissolution. On the other hand, third parties are free to enforce any claims they may have against unregistered firms or partners in such firms. Statements regarding the constitution of a firm which are recorded in the register are conclusive proof of the facts they contain against the partners making them. Provision is made for the registration of changes that may take place in the constitution of firms from time to time. The main object of the provisions dealing with registration is to enable persons who wish to enter into transactions with a firm to know who will be liable as partners for the debts of the firm. Although the Indian Partnership Act is applicable to the whole of British India, including British Baluchistan and the Sonthal Parganas, the Governor General has the power to exempt any province or part of a province from the application of the provisions of the Chapter on registration of firms. Such exemption can be granted by a notification to that effect in the *Gazette of India* (See s. 56, I. P. A.). This power has been reserved to the Governor General in order that he may exclude, from the operation of the registration clauses, areas which are so backward commercially that more harm than good might result from their application.

The only particulars to be furnished to the Registrar for registering a firm are the name of the firm, the place or places where the firm carries on business, the date on which each partner joined the firm, the names and addresses of the partners and the duration of the firm. This is the minimum information that a member of the public intending to enter into dealings with a firm ought to have. It will be noticed that registration does not involve the disclosure of the internal affairs of the firm (*Vide* s. 58, I. P. A.). The Registrar being only a recording officer is bound to record any statement which complies with the prescribed formalities without inquiring into the truth of its contents. Changes in the name of a firm which has been registered, or in its principal place of business, may be reported to the Registrar to enable him to bring the Register up-to-date. The reporting is not at all obligatory, but it needs to be done with all the formalities which are required to be observed for the registration of the firm in the first instance. All the partners, or their specially authorized agents, must sign and verify the statement in both cases. Changes in places of business other than the principal one, in the names and addresses of the partners, and in the constitution of a firm, and the dissolution of a firm, may be notified by any person who was a partner before the dissolution. The Act makes provision for the rectification of mistakes by the Registrar, the amendment of the Register by an

order of the Court, for the inspection of the Register and filed documents and the grant of certified copies of entries in the Register of Firms.

The only penal section in the Act prescribes a penalty of imprisonment or fine for making a statement which the person making it knows to be false, or does not believe to be true, or which he knows to be incomplete or does not believe to be complete.

As already pointed out, there is no positive duty to register a firm, but non-registration involves certain disabilities. It may be said that in this way indirect pressure is brought to bear on firms to register. Section 69 of the Act is the pivot of the scheme of registration adopted by the Indian Legislature. It prevents an unregistered partner in an unregistered firm from filing a suit to enforce a civil right arising out of a contract, or conferred by the Act, against the firm or any other partner. The disability extends to a claim of set-off or other proceeding to enforce a contractual right. An unregistered firm is equally incompetent to file a suit or other civil proceeding against third parties to enforce rights arising from a contract. There are, however, certain exceptions to the disability imposed by the section. Thus, a right to sue for the dissolution of a firm, or for accounts of a dissolved firm, or a right to realize the property of a dissolved firm can be enforced by an unregistered partner against an unregistered firm. This exception is based on the principle that, registration being primarily intended for the protection of third parties, the absence of registration need not come in the way of the disappearance of an unregistered firm. The section also leaves intact the powers of an official assignee, receiver or Court to realize the property of an insolvent partner. Firms and partners doing business outside British India, or in places in British India to which the provisions of Chapter VII are made inapplicable by a notification under section 56 of the Act, are exempted from the operation of section 69. Certain suits and proceedings are also excluded from the scope of the section by reason of the smallness of the stake involved, or the comparatively minor nature of the claim. Thus, suits and claims not exceeding one hundred rupees in value, and not excepted from the jurisdiction or cognizance of the Presidency or Provincial Small Cause Courts, are expressly excluded from the operation of the section. Claims by way of damages for civil wrongs and criminal proceedings would also fall outside the purview of the section. Registration can be effected at any time, and an unregistered firm or partner can get over the disability imposed by section 69 by registering immediately before embarking on litigation. It has been argued that, if the object of registration is merely to provide for the disclosure of the names of all the partners in a firm, then registration is unnecessary,

as that purpose is fully served by Order XXX Rules 1 and 2 of the Code of Civil Procedure, which provide that:—

R. 1. "Any two or more persons claiming or being liable as partners and carrying on business in British India may sue or be sued in the name of the firm of which such persons were partners at the time of the accruing of the cause of action, and any party to suit may in such case apply to the Court for a statement of the names and addresses of the persons who were at the time of the accruing of the cause of action, partners in such firm, to be furnished and verified in such manner as the Court may direct."

R. 2. "(1) Where a suit is instituted by partners in the name of their firm, the plaintiffs or their pleader shall, on demand in writing by or on behalf of any defendant, forthwith declare in writing the names and places of residence of all the persons constituting the firm on whose behalf the suit is instituted.

(2) Where the plaintiffs or their pleader fail to comply with any demand made under sub-rule (1), all proceedings in the same suit may, upon an application for that purpose, be stayed upon such terms as the Court may direct."

The answer to the above argument is obvious. The Register of Firms being a public document is open to inspection at any time, and enables any one who desires to know who the partners are to get the information he wants without any difficulty. On the other hand, the institution of a suit is not a matter of common knowledge, and the rules of a particular Court may prevent a stranger to a suit from inspecting the records of a pending suit. Further, Order XXX does not avoid the necessity of determining the issue whether a particular individual whose name is not disclosed is a partner or not. If the names of the partners are previously registered, it is not likely that the name of one who was a real partner would be suppressed, in view of the penalty of imprisonment and fine which the making of an untrue statement involves. It is the experience of lawyers that the man of substance sometimes keeps in the background, and puts forward a man of straw as the partner so that, in the event of the firm coming to grief, the former may escape with impunity. The public are thus deceived, and the real truth can only be discovered after the trial of the issue of partnership in a legal proceeding, usually in the execution stage. In practice, it is not likely that firms will put off registration until they are on the brink of litigation. A third party wishing to have dealings with an unregistered firm may for his own protection insist on the firm being registered before he enters into any transaction with the firm. After a time, the public would look upon an unregistered firm with

some suspicion. Thus, even though the provisions in the Act relating to registration are optional, public opinion and public interests will have the effect of making registration the rule rather than the exception, even in the absence of litigation.

It was contended by some of those who were opposed to the practice of registration that it would be a hardship to require ignorant and illiterate villagers who may be doing business in partnership on a small scale to go through the procedure of registration of which they may not be aware. The supposed hardship is, however, more imaginary than real because registration becomes necessary only when litigation is contemplated, and even the ignorant villager has to seek the assistance of a lawyer when he wants to enforce a legal right, and the lawyer, if he knows his business, is sure to take the precaution of getting the firm registered in order to get over the disability imposed by section 69 of the Act. Again, it is no greater hardship to require a firm doing business on a small scale to register than to require a purchaser of immoveable property of the value of a hundred rupees to register his sale-deed. The ignorance of village-folk has not come in the way of enforcing the provisions of the Indian Registration Act.

From the discussion in the preceding pages it is evident that the system of registration of firms, adopted for the first time in British India, has many real advantages. It affords protection to the public against fraud. It enables businessmen to know the persons whom they can look to for the fulfilment of their contracts, and makes the evasion of liability by partners almost impossible. It is to be hoped that by taking advantage of the procedure of registration firms will be able to carry on their business in an atmosphere of mutual confidence and trust, which is essential for the prosperity of commerce and trade in any civilized country. By making registration optional the Legislature adopted the line of least resistance. Sooner or later, however, compulsory registration, as in England, will have to be introduced into India, unless the trading community realizes the advantages of registration, and avails itself of the useful machinery provided by the Act. Joint Hindu family businesses have been left untouched by the Act, and rightly so, because an attempt to legislate for them would have made the enactment too complicated for the average businessman and the busy trader to understand without intellectual effort. Ordinary partnerships arising out of contract, to which alone the new Partnership Act applies, will in the long run gain more than they will lose by taking the fullest advantage of the provisions relating to registration. Those who were at one time opposed to legislation on these lines will soon realize that their fears were unfounded, and that the publicity which registration involves to a certain extent, instead of injuring

the interests of the trading community, is calculated to improve the conditions in which business is done and to create confidence in those who enter into dealings with mercantile firms.

S. R. DONGERKERY

INAMI LANDS IN BOMBAY CITY

The lands in Bombay which fall under this tenure are situated mainly at Naigaum, Parel and to the North-East of the Sion Fort. Small parts lie near Dadar and Dharavi. Inam lands pay no assessment to Government nor judi nor cess of any kind. The area is roughly about 571,294,08 sq. yds or 878 acres. Mr. Vaidya in the 2nd edition of his book at p. 109 says, however, that the area is 1,181 acres. They are comprised in three grants made to the Lowjee Wadia family by Government in the years 1783, 1828 and 1885.

(1) THE FIRST GRANT.

The act of shipbuilding was introduced into Bombay by the family of Lowji the master shipbuilder in the year 1735. He had rendered extraordinary services to the Government and this was recognised in high esteem by several heads of various departments of the then Government. In 1783, Sir Edward Hughes, K. B., Commander-in-Chief of His Majesty's ships in India, having brought to the notice of Government the very essential and important services rendered by the Parsi master-builders Manockji and Bomanji Lowji and their two sons Framji and Jamshedji Lowji, in refitting His Majesty's Squadron, recommended a grant to the family, of a portion of the Company's Batty Grounds producing a net income of forty morahs of batty annually. The said grant was in the following terms:—" This is to certify that Vice Admiral Sir Edward Hughes, K. B. and Commander-in-chief of his Majesty's ships and vessels in the East Indies, having by letter under date the 10th March, 1783, pointed out the great services rendered the nation at large, and the United East India Company, by Manockjee Lowjee and Bomanjee Lowjee, the two master builders at this Presidency; and having also strongly recommended to us to confer on them a certain portion of ground on this land which will yield annually forty morahs of toca batty i.e., rice lands, this is to certify that the said Manockjee Lowjee and Bomanjee Lowjee have accordingly been put in possession of certain batty (a) grounds in the district of Parell with their *foras* and *purteneas* (Portuguese words signifying out-lying or waste lands) of the side grounds, which will yield the above quantity of toca batty; and that they are to be kept in possession of the same, without molestation until the pleasure of the Honourable the Court of Directors is known. Given under

our hands in Bombay Castle this 29th day of December 1783." The Board of Directors of the East India Company accepted and confirmed the recommendations of the Commander-in-chief 12 years after the date of the grant by their letter dated 28th April 1795 which ran in the following terms:—" Observing by your advices of 30th September, 1783, and 10th February 1784, that you were induced to issue the beforementioned grant to the two master builders and their sons, at the earnest recommendation of the late Sir Edward Hughes, as a reward for the essential and important services they have rendered the nation, and the Company in particular, in refitting his Majesty's squadrons; and as we ourselves have borne frequent testimony of their merits, we hereby ratify and confirm the said grant, with a due proportion of *foras* and *purtencas* to their family and descendants."

Mckenzie v. Pestonji Dadabhai

This grant has been the subject of judicial construction in the case of Doe Dem Mckenzie *v.* Pestonji Dadabhai reported in Perry's Oriental Cases at p. 531. Under this grant the family became possessed of a large quantity of land, principally waste, and of little value at that period but which, with the growth of population and wealth in the island, became very valuable thereafter. In the year 1823, the estate thus granted was in the possession of the descendants of the original grantees, but the family having ramified into various branches, they agreed to divide the estate amongst them and the portion called the Lal Bagh fell to the lot of Dadabhai and Mancherji Pestonji, who from that period had its exclusive possession, and who resided there with their families. In November 1850, these gentlemen mortgaged the Lal Bagh estate for Rs. 60,000/- to secure the repayment thereof and interest thereon and gave the mortgagee a power of sale in case of non-payment. Subsequently in the same year, i. e. 30th December, 1850 they stopped payment and became insolvent and conveyed the estate and effects including the equity of redemption in trust to the lessors *of the plaintiffs* for the benefit of their creditors. The trustees brought a suit for ejectment to recover the said Lal Bagh estate belonging to Messrs. Dadabhai and Muncherji Pestonji. This action was defended by the son of Dadabhai Pestonji who claimed and contended that the estate was inalienable, being a grant from the Government for services performed and that his father Dadabhai had under the circumstances no right to grant any more than a life interest in the property. The main question for the decision of the court was, whether the Lal Bagh estate which formed part of the original grant was alienable or not. The matter came up for decision before Sir Erskine Perry C. J. who held that the effect of the documents under which the grant was made was to

give the grantees a complete grant of the estate in fee of the lands so granted and did not render the estate inalienable as contended by the defendant. The result of the learned judge's decision thus appears to be to put the estate given by the Government under the said grant on a footing of equality with an ordinary freehold estate. Dealing with the question at issue the learned judge after setting out the facts observed at p. 533 of the report: "The argument which is set up on behalf of the inalienability of this property is two-fold (1) it is said that when the Crown grants lands in tail with reversion to itself for services performed, the reversion cannot be barred, as it can in any other case, so as to exclude the Crown's right. (2) By a regulation of the Bombay Government, XII of 1827, ch. 9, lands granted in Jaghir may be resumed at the pleasure of Government. On the analogy of these two rules it is contended that the grant of the Lal Bagh estate must be considered not as a grant in fee, but a grant for the benefit of this family only, and therefore inalienable.

But the answer to these arguments is obvious. The grant in question does not create an estate tail, and the reversion is not reserved to the Crown; any inferences therefore deducible from the technical rules relating to English conveyancing, or to the rights of the prerogative, are inapplicable. Although English law has been introduced into this land to the supercession of the Portuguese feudal law, which appears to have prevailed at the period of the cession (and it may not be very easy to define the exact judicial mode by which the change was effected,) the forms of English conveyancing have never been in use, and the oldest practitioners have never heard of a fine or recovery. Land therefore passes from hand to hand with all the simplicity of a transaction not fettered by forms; and all that we see in Courts of justice on such occasions is a simple writing, not under seal, expressive of the intention of the parties. It is the duty of the Court to put a construction upon such instruments when brought before it; and in the present case, on looking to what the Court of Directors call the grant by the Bombay Government, and to their own confirmation of it, I feel no doubt *that the effect of those documents was to give the grantees a complete estate in fee of the lands so granted.*"

Howard v. *Pestonji Dadabhai.*

In connection with the grant of 1783 just discussed, another case viz. *Doe Dem Howard* v. *Pestonji Maneckji* reported in Perry's Oriental Cases at p. 535 and decided a month earlier in the same year i.e., 1852 by Perry C. J. and Yardley J. though it does not throw any fresh light on the nature and tenure of the grant will be found interesting.

This was also an action of ejectment brought by the same trustees of the said two Pestonji brothers against Pestonji Manockji the defendant as representative of the Parsi community. The Pestonjis were, prior to 1834, as we have seen, jointly possessed of the large freehold estate, called the "Lal Baug," on part of which they erected their dwelling house, where in or about 1824 they erected a Fire Temple in a part of the garden at the back. The building of the temple with the outhouses and appurtenances covering about 2,387 square yards of ground was duly consecrated and the sacred fire placed according to the rites and ceremonies enjoined by the Zoroastrian religion and was set apart as a place of charity in or about August, 1834 in the presence of the leading members of the Parsi Punchayat and of the community assembled within the precincts of the temple. In the presence of the public assembly the Pestonjis caused a document to be read and promulgated and declared that they had built the temple and placed the sacred fire in the sacred memory and commemoration of their deceased father, but that the fire temple and the priests officiating therein should always be subject to the authority of themselves and their heirs and that all the members of the Zoroastrian community were to be at liberty to have their religious ceremonies performed in the temple without any objection on their part. On these facts the question for the decision of the Court was whether the defendant on behalf of the Parsi community was entitled to the said temple and the ground on which it stood and to exclude the lessors of the plaintiffs from the same. It was contended for the plaintiffs that as the Pestonjis had retained the property of the temple in themselves, the instrument under which the defendant claimed, amounted at the utmost to a license by Dadabhai Pestonji to attend the temple, as there was nothing to prevent him from changing his mind the next day and using the temple for some other purpose. On the other hand it was contended for the defendant that the instrument operated as a grant of the temple to the Parsi community or that at all events it amounted to a dedication to them for the purpose of performing their religious rights and that it was the universal custom among the Parsis that a temple devoted to religious purposes could not be used in any other manner.

It was held by Perry C. J. and Yardley J. that the Pestonjis, by adopting the course they did, had performed no act and incurred no obligation by which they had denuded themelves of the full right of ownership to the temple and to the land on which it stood. On the contrary they had intended to retain the property in the temple in themselves and their heirs forever and had not even bound themselves to maintain and repair the temple and the instrument could not be

construed to contain a grant of the temple to the Parsi community, even though they intended, no doubt, that the temple should never be used for any purpose other than the religious ceremonies common to the Parsi community for which the temple was dedicated, for the mere fact of dedication to a particular use only implied that the ownership remained with the grantor. The learned judge further held that as the Pestonjis had become insolvent, the right of ownership passed as a matter of course to their assignees or trustees. Yardley J. agreed with the Chief Justice and held that the Pestonjis had no intention to make a grant of any portion of their land away from themselves or their heirs either to the Parsi Community generally or to any one or more persons in trust for them as the instrument contained no words of grant or conveyance, no person being named or even described as grantees to say nothing of the large reservations to themselves and their heirs. The learned judge therefore held that the true legal effect of the instrument as to the right of all Parsis to use the temple was at the utmost that of a mere license revocable at the pleasure of the grantors the Pestonjis and that no estate or interest in the temple passed out of the Pestonjis or to any one else whomsoever and that therefore, as the ground on which the temple stood was part of the Lalbagh estate, it passed with the rest of it to the lessors of the plaintiffs.

In March 1920 on a reference from the Collector of Bombay, the Government passed orders authorising the Collector to levy assessment on all lands under this grant (viz., the grant of 1783) which had passed out of the possession of the Wadia family on alienation by sale and several notices in consequence were issued by the Collector of Bombay. Several holders protested against the proposed levy of assessment and the Morarji Goculdas Spinning and Weaving Co. Ltd. filed a suit against the Collector of Bombay being suit No. 1 of 1921. The Advocate General who was consulted stated that in his opinion the grant of the land comprised in the document of the 29th December 1783 was an out and out grant and that Government were not entitled to assess the lands. Government agreeing with the view of the Advocate General cancelled the defence of the suit which was by consent allowed to be withdrawn. The notices of assessment against the other holders were also withdrawn. Vaidya's Land Revenue Code (1931) 2nd Edition pp. 107–108.

Morarji Goculdas Spinning & Weaving Co. Ltd. v. The Collector of Bombay.

(2) THE SECOND GRANT

The second grant was made in the year 1821. On the 12th Sept. 1821, the Government of Bombay was pleased to comply with an application from the late Jamsetji Bomanji Wadia who was a master

builder in the Dockyard and who died on or about 31st of August 1821, for cultivated lands yielding an annual rent of Rs. 6000/-. The grant was made to him to testify to the Company's approbation of his eminent and faithful services in that capacity, and was intended to be made by transferring to the heirs of Jamshedji the revenue accruing from and payable to the Government for and on account of certain lands situate in the Island of Bombay and Salsette under a formal agreement that the then prevailing assessment should not be increased and securing to the Curumbees the right of cultivation and all other privileges and with the stipulation that in the event of the usual assessment being increased or any other modification introduced in the then existing system by the Government, the same should have operation within the villages to be granted.

In January 1822 the Government authorised the Collector to put Nowroji Jamshedji in possession of the batty grounds situated in the villages of Parel, Naigaum-Sion and in the Casabay (Kasba) of Mahim yielding an annual revenue of Rs. 2000/-. On the 2nd February 1822 Nowroji signed a declaration agreeing to adhere to the engagements particularised in the orders of Government dated 12th September 1821 and in October 1827 a formal deed of Gift or Sanad was made between the Government and Nowroji Jamshedji, Muncherji Jamshedji and Dossabhoy Jamshedji, the sole heirs of the Jamshedji Bomanji Wadia, whereby they were authorised to collect and receive revenue as and when the same may become due and payable and to enjoy the same as and for their own sole and absolute property. A copy of this deed which was executed by the parties on 29th May 1828 is given in the Schedule A attached hereto. The Government was also pleased to grant lands to the family of the late Jamshedji Bomanji on the island of Salsette yielding an annual rent of Rs. 4000/-.

The lands at Sion in Bombay became intermixed with Government land and it was thus made difficult to collect the revenue. Nowroji therefore made a petition to the Government in 1854 praying that he may be allowed to exchange the produce of the land at Sion with the above villages in Salsette viz., that he may be allowed to retain the sum of Rs. 711, the surplus revenue of the two villages of Illaparla (now Villeparle) and Jhoo (now Juhu) in return for which the Government may be pleased to retain the revenue of the land at Sion and also pleaded for a reduction in the amount of the annual subsidy paid by them to the Government. At the recommendation of the Collector, the Government was pleased to comply with Nowroji's request for the exchange taking the exchangeable value of his land at Sion to be Rs. 511/- per annum on condition that the difference between this sum and the Khoti rental paid by him

should be made good to the Collector of Thana. The terms were accepted by Nowroji and a formal deed of exchange was drawn up and executed by the parties in 1855. The Sion Inam lands thus reverted to Government and have since been held by the tenants on the Toka tenure.*

In August 1879 Government sanctioned an increase of assessment for Toka lands and in July 1882 notices were given to the Toka holders under the Government of the increase in the assessment. The Inamdars were also advised to assess the lands granted to their predecessors by the Indenture of 29th May 1828 on a revised scale on the strength of the power alleged to have been reserved to them under the said deed. One Cursetjee Nowrojee Wadia, one of the Inamdars who was the owner of a large piece of land containing about 39,187 sq. yards at Chinchpokli claimed to be entitled to increase the Toka rent or assessment at one pie per square yard payable in respect of the said land which was occupied by Messrs. E. D. Sassoon and Co. who according to him were liable to pay to him rent therefor at such increased rate viz., the sum of Rs. 204-1-3 per annum from the year 1886-87 on the strength of the said Government orders. Messrs. E. D. Sassoon & Co., however, refused to pay the increased assessment in spite of demand and hence C. N. Wadia brought a suit in the High Court being suit No. 439 of 1889 against Messrs. E. D. Sassoon and Co. for a declaration that he was entitled to increase the assessment as he was seeking to do. It may be stated here that similar notices were given by other Inamdars to their tenants who also refused to pay the assessment at the increased rate as demanded. The suit between Wadia and the Sasoons was thus a test suit.

Cursetji N. Wadia, v. E. D. Sassoon & Co.

It was contended on behalf of the plaintiff that he was in the shoes of the Government and that he was entitled to receive what Government did or would do and that he was entitled to have the benefit or was bound to bear the burden of the change in the assessment which enabled Government to enhance the rent. It was argued for the defendants that though the Government might have the right to increase the assessment or take it themselves, the plaintiff had not the right either to increase or take it, as he was precluded from doing so by virtue of the provisions of the Deed dated the 29th May 1828 and that therefore he was not entitled to have the declaration and reliefs claimed by him in the suit.

Parsons J. who heard the suit held that the plaintiff was entitled to increase the Toka rent and assessment payable in respect of the

* *Cf. The Gazetteer of Bombay City & Island*, (1909) edition, Vol. II, pp. 375-378.

land occupied by him in the suit. His Lordship thus confirmed the right of the Inamdar to charge the assessment on a revised scale and increase the same. His Lordship delivered the following (unreported) judgment:— The Deed in question conveys to the plaintiffs all and every the rents and produce, sums and sum of money now due and of right payable or which shall or may at any time or times hereafter be or become due and payable as for or in respect of revenues collected or arising on and from the several pieces or parcels of ground......... It is thus *not a grant of the soil, but is a grant of the revenues, in other words, a grant of the Government renenue.* It is not a grant of merely the revenues set out in the schedule, then that would have been so stated. But it grants all the revenue that shall or may at any time or times hereafter become due or payable. The amount in the schedule is only an approximation, a statement what might on an average be expected to be realised. We find indeed, that constant changes have been made in this. The value, of course, would vary as the prices of grain varied and be more or less each year, but even the payment of kind have for years past ceased and been converted into a money payment. The clause that the grantee should not have the power of himself to enhance the amount payable appears to be insisted on by Government for the protection of the cultivators. It thought perhaps that under the wide grant of the revenues, a power to enhance the rent might be assumed by the grantee. In order to guard against that and protect the rights *ex majore cautale,* an express prohibition was made viz., that the grantee was not to enhance the rent, but was only to take the revenues that were then legally leviable. At the same time, however, it was expressly provided " that in the event of the land assessment being at any future time increased by Government or any other modification being introduced into the then existing land revenue system of the Island of Bombay, such alteration shall extend to and have operation in the said lands in the same manner and as fully in all respects as if these presents had never been made and granted." The meaning of this is, in my opinion, not as argued for by the defendants, that it is a modification as such of the grant to be at an end or that the Government were to take the increased assessment, but that the grantee was to be subject to the modification. If the revenue was increased, he would gain, if decreased he would lose. In that respect the presents were to be as if they had never been made. There was clearly no intention on the part of Government to create a higher favoured class of ryots enjoying these lands on payment of a fixed rent far below that paid by other ryots. On the contrary, the intention clearly was that the ryots of this land should pay for

the soil the same (rent) as the ryots of other similar Government land. The one was to be as much subject to modification of the revenue system as the other. The argument that the Government only was to take the increased revenue is opposed to the very plain terms of the grant of the revenues themselves and it is impossible to suppose that had such been the intention, it would not have been expressly so stated. A reference to the Collector as to what is the revised assessment on the lands in question under the rules now in force, as to the assessment of Toka lands such as those in suit is not necessary, since it is admitted that Government have increased the assessment of such lands and fixed it universally at one pie per square yard on all such Government lands in the village of Parel. This is an increase of assessment by Government and a modification in the land revenue system of which the plaintiff can take advantage."

His Lordship therefore held as already stated before that the plaintiff was entitled to increase the rent or the assessment of the lands held by the defendants and that he was entitled to the declaration and reliefs claimed in the suit. From this decision there was an appeal being No. 629 of 1890 wherein it was contended that the plaintiff was not entitled to increase the rent payable by the defendants in respect of the lands occupied by them and that the defendants were not liable to pay the increased rent. The Court of Appeal consisting of Sargent C. J. and Bayley J. gave liberty to the plaintiffs to amend the pleadings and the proceedings by making the Secretary of State for India a party defendant to the suit and ordered a retrial of the suit.

The plaintiff's solicitors thereupon requested the Collector to obtain a declaration that the grantees were entitled to increase the rent. The Advocate-General advised the Collector to grant no such order until it was decided in the suit that the Inamdars were so entitled. He thought that the terms of the document were so obscure that it was possible on one construction to argue that under the terms, any enhancement should go to Government and not to the over-holder.

The Collector Mr. (afterwards Sir James) Campbell, in a letter of April 1891, observed as follows:—"The present grantee seems to me to occupy the position of an Inamdar. *The received relation between an Inamdar and Government is, I believe, that Government make over to the Inamdar their share and interest in the revenue of the land.* When under a revised settlement the Government rates in Government lands are enhanced, the usual position is that the Inamdars of neighbouring and similar land are entitled to enjoy a similar enhancement of rents from their tenants, Government claiming no share in the Inamdar's additional

receipts. Though under ordinary circumstances the enhancement would pass to the Inamdar or grantee, I agree with the Advocate-General that in the present case it is at least open to question whether it was not the intention of Government in 1828 to limit the grantees' interest to the (then) existing rents estimated in the deed at Rs. 2,000 and to reserve to themselves the right to any enhancement on the lands in question which a revision of settlement might realise." Vaidya's *Land Revenue Code* (1931) 2nd Edition p. 110.

The Collector agreeing with the Advocate General suggested that Government should accept the position of parties to the suit and instruct their law officers to press the Government claim to the increase recoverable under the revised settlement rates. Government concurred in the view taken by the Collector and passed a resolution on the 21st April 1891 to that effect. But before the Secretary of State was made a party to the legal proceedings in the High Court, the suit between the Wadias and the Sassoons was compromised by mutual agreement and the points at issue remained judicially undecided.

On the 26th June 1895 the executors of Mr. Cursetjee Nowrojee Wadia made a petition to Government requesting consideration of the following points:—"(1) That the terms of the grant were quite explicit and gave the grantees authority to charge assessment from time to time on the same scale as might be fixed by Government for similar lands (2) that some time after the grant was made, Government having reduced the rate of assessment on their toka lands, the Inamdars were obliged to do the same as regards their own lands (3) that the tenants of the land were all entered not in the Collector's books but in their own (4) that in the villages in the Thana District of which grants were made in a similar way, they raised the assessment and were receiving it from the tenants without any objection (5) that Government in reassessing their own lands excluded the land covered by the Indenture, and (6) that it was clear from the grant that it was never the intention of Government to create a favoured class of ryots enjoying their lands on the payment of a fixed rent far below that paid by other ryots."

To this petition Government sent the following reply:—"Government, without foregoing any claim the public exchequer may have to the amount by which the assessment may be enhanced, have no present intention of recovering that amount on their own account or of interfering with the recovery of it by the petitioners." A further reference was made by the Collector to Government regarding their claim over the Inam lands under acquisition for the City Improvement Trust. Government in April, 1909 directed that no claim on the part of Government should be made in respect of land

held as Inam by the Lowji family under the grants of 1783 and 1828.*

In connection with the second grant just described, we might as well refer to the case of *Jamshedji Ardeshir Wadia* v. *The Secretary of State for India* [(1926) 28 Bom. L. R. 25]. On Appeal to the Privy Council, *Bomanji J. Wadia* v. *Secretary of State for India* (1929) 31 Bom. L. R. 256 (1929) 53 Bom. 230 which was a case of a somewhat similar grant to the Wadia family of certain villages in Juhu and Ville Parle in the year 1848.

In this case the facts were as follows. In the year 1817 the East India Company granted a pension of Rs. 200/- per month with a suitable grant of cultivated land in Salsette to their master builder Jamshedji Wadia on his retirement from service. Mr. Jamshedji B. Wadia died on or about 31st August 1821. Prior to his death he had made an application to the Government for a grant of cultivated land yielding an annual rent of Rs. 6,000/- and the Government of Bombay were pleased to comply with the said application in October of the said year whereby the grant was made to him to testify to the Company's approbation of his eminent and faithful services in that capacity, of lands yielding an annual revenue of Rs. 6,000/-. Rs. 2,000/- of that grant to be assigned from lands in Bombay and the additional sum of Rs. 4,000/- to be allowed by a deduction from the revenue payable by one Hormusji Bomanji as a land-holder of Salsette without affecting the term on which he held the lands. The above arrangement received the approval of the Court of Directors on 6th October 1822.

On 31st March 1841, the revenue payable by Hormusjee Bomanjee to Government was redeemed. The grantee thereupon applied to Government for a grant of other lands in Salsette the revenue of which might be Rs. 4,000/- a year. The villages of Juhu and Ville Parle were found suitable to be made over to the grantee. The revenues of the villages as calcuated on the Jamabandhi of 1842-43 were found to be Rs. 4679-1-8 to which was added the sum of Rs. 20-14-3 the revenue of brab trees. Thus out of the total amount of Rs. 4700/- the grantee was allowed to retain Rs. 4000/- as the amount of his Inam and he had to pay the balance of Rs. 700/- every year to Government. It was then pointed out to the grantee that he could have no claim to anything not expressly conveyed to him and that all ground required for roads or other public purposes should be given up on the usual terms. A formal grant was issued by the Government on 9th February 1848 which

*Cf. *The Gazetteer of Bombay City and Island* (1909) Edition, Vol. II, pp. 380, 381. The wording of the third Inam Grant of 1885 was, as we shall presently see, very clear and no orders on this point were applied for.

recited that the grantee Nowroji Jamsetji Wadia made an application to Government for the grant of villages in Salsette the revenue of which would be Rs. 4000/- and that the villages of Juhu and Ville Parle might be assigned to him and his heirs in perpetuity from the year 1847-48 which request was granted by the Government. The deed then gave a long and minute description of the villages and the various lands from which the revenue was levied calculated partly on the lands and partly on the produce of brab trees tapped for toddy and also a detailed statement of the revenue paid by the sutidars (occupant owners) amounting to Rs. 4679/. From this amount, the amount of the applicants Inam of Rs. 4000/- was deducted, leaving a deficit payable of Rs. 679/-. The said deed contained *inter alia* the following provisions.—

3. You are to pay the above sum into the Collector's Treasury, into that of the District, or the General Treasury at Bombay, on or before the 1st April on each year, on failure of which payment you will be proceeded against agreeable to the regulations.

4. In the event of the sweet and salt waste land stated in the 1st clause of this lease being cultivated, it will be made liable to the usual rates of taxation allowing you at least ten years exemption for the arable and twenty years for not arable waste, commencing from the year you would undertake to bring it under tillage, and of which you are to give previous notice to the Collector.

5. Should any of the swampy ground now covered by the sea at spring tides become available for cultivation or the construction of salt-pans by the operation of natural causes, or by embankments which you may erect, it will be liable to the payment of such amount of revenue as may hereafter be fixed.

11. You are not to alter the present mode of assessment nor to introduce any new tax but to collect your rents from the ryots according to the commutation rates as they may be fixed from time to time for the Island of Salsette. You are not to fix your instalments earlier than those fixed for the Government Villages, though you may postpone them to a later period should you wish it.

12. In the event of the land assessment being increased or any other modification introduced in the existing revenue system of the Island of Salsette by the authority of the Government, the same shall have operation within the villages hereby granted to you.

13. You are to bring to the notice of Government any instance in which any land &c. in your villages belonging to Government may have been fraudulently concealed or enjoyed without payment of

revenue, when the necessary steps will be taken to assess them but you have no power to do so.

16. In the event of any quantity of ground being required by Government for roads or other public purposes, it should be given up by you on the usual terms of the mere remission of the assessment if the land in question be cultivated.

20. It is clearly to be understood that this deed confers no right which Government does not now possess and only such portion of the rights of Government as may be herein specifically granted is hereby granted to you.

21. In the event of the failure of heirs the villages now assigned to you are to revert to Government.

The grantee went into possession of the villages and continued to make the stipulated payment to Government.

In 1873 Government appointed one Col. Francis to take steps for the revision of the assessment of the two villages with a view to recover surplus revenues, after deduction of Rs. 4000/- per annum payable to the grantee. The revision survey settlement was introduced in 1886, with the consent of the grantee. It brought an additional amount of revenue. The Government made over the surplus revenue to the grantee. In 1896 the Chikhli or waste lands in the villages, which had since the date of the grant been brought under cultivation, were attempted to be assessed but the Government gave up the attempt. It appears that whenever land in the villages was acquired under the Land Acquisition Act, compensation was paid to the grantee as if he was the proprietor.

In November 1916, the Government commenced survey of building plots in Ville Parle with a view to levy non-agricultural assessment and to appropriate it to themselves and imposed on lands in one of the villages non-agricultural assessments under the Bombay Land Revenue Code, 1879, section 48, sub-section 2, and rules made in 1907 under section 214 of that Act. It was common ground that the village was an "alienated village" as defined in sec. 3 of the Code.

The protests of the descendants of the grantees made to the Salsette Development officer, the Collector and lastly to the Commissioner having failed, the grantees eventually in February 1918 filed a suit to have it declared that under the grant they as owners were entitled to levy non-agricultural assessment in the village of Ville Parle and to appropriate it to themselves. They also filed a separate suit for a declaration that in any event the lands in their actual possession and enjoyment were not liable to the assessment. A good deal of correspondence took place between the parties before the grant was

made in 1848. Subsequent to the grant the Government had adopted certain lines of conduct in dealing with the grantee with reference to lands in the village. The plaintiff relied on both these pieces of evidence to construe the terms of the grant. The District Judge held that the grant of 1848 was neither an absolute grant of the soil nor a mere assignment of the revenue but that it was merely an assignment of Rs. 4000/- out of the revenues of the village, that the liability of the grantee was not restricted to an annual payment of Rs. 700/- but could be increased in the event of increase in the revised assessment, that the plaintiffs were not entitled to levy non-agricultural assessment, but that the Government were so entitled and that the lands in the actual possession and enjoyment of the plaintiffs were exempt from non-agricultural assessment. On appeal Sir Norman Macleod C. J. and Madgavkar J. came to the same conclusion, though by a different process of reasoning and held that the Government intended by the grant to provide the grantee with an annual income of Rs. 4000/- reserving to themselves all other rights, that the Government had therefore the right to levy non-agricultural assessment on maltep or warkas land that had passed out of the possession and enjoyment of the grantee under the deed of 1848, that the maltep or warkas lands in the actual occupation and enjoyment of the grantee were exempt from non-agricultural assessment by Government.

From this decision, Wadia appealed to the Privy Council.

The main question on the appeal was as to the construction and effect of the deed of grant dated 9th February 1848 by the East India Company in favour of Nowroji Jamsetji, the predecessor-in-title of the appellant. It was held on the construction of the deed that the effect of the deed was that it was a grant of the villages subject to the conditions attached and not merely an assigment of Rs. 4000/- per annum out of the revenues of the villages. It was also held that condition 20 of the deed did not apply as the Act of 1879 by s. 48 did not provide for an additional assessment, but only for an altered assessment to be imposed according to rules and once the building assessment was imposed, the old agricultural assessment would go for ever and thus the non-agricultural building assessments were merely in substitution of the former assessments and the appellants were entitled to be credited with the amount assessed upon the land occupied by the sutidars, as it was not practicable to fix the applicant's share in the proportionate manner referred to in r. 5 of the revenue rules of 1907.

(3) THE THIRD GRANT.

The third grant was made in 1885 to Khan Bahadur Jamshedji Dhanjibhoy Wadia in consideration of the exceptional service

rendered by him during his long official career extending over a period of more than forty years in his Majesty's Dockyard. Mr. Wadia had taken an active part in the arrangements for fitting out the expedition for Persia, Abysinia, Malta, Afghanistan and Egypt and had well-maintained the ancestral reputation of his family.

His request which was for plots of lands then valued at Rs. 55100/- was considered out of all proportion to the services rendered and the Local Government was only prepared to move the Government of India to sanction the grant of land valued at Rs. 10000/- to 12000/-. Mr. Wadia was asked to select in consultation with the Collector of Bombay such pieces of Government waste land as were available. Three plots of land, two at Dharavi and one at Sion containing an aggregate area of 307 and not 337 (as stated by Vaidya in his book on the Bombay City and Land Revenue Act (1931) 2nd Edition at p. 109) acres or 1485,880 sq. yds. were selected. The sanction of the Government of India was applied for and obtained on the 17th June 1885. The grant was made rent-free in perpetuity subject to the payment of all taxes etc., chargeable and the condition that he should not interfere in any way with the supply of water to the salt pans in the neighbourhood of the Sion land and should not interrupt the free passage of the storm water through one of his plots at Dharavi. The deed was executed on the 19th December, 1885. Copy of the deed is given in the schedule B attached hereto. Cf. *The Gazetteer of Bombay City & Island*, (1909) Ed., Vol. II, pp. 378-379.

SUMMARY.

To sum up the law on the subject of the Inami lands in the City and Island of Bombay, the first grant made to the Wadia Lowji family in the year 1783 is, as we have seen, an absolute grant of the land together with the revenues and all other rights and privileges attached to the ownership of a freehold estate. The Instrument of Grant granted to the grantees, to use the words of Perry C. J. "a complete estate in fee of the lands so granted" with full and absolute power of alienation and transfer by sale, mortgage, gift, exchange, lease or otherwise of the lands so granted subject to the usual restrictions and limitations imposed by the ordinary law of the land, statutory or personal, local or special. The grant being absolute, even the Government have no power to levy any assessment much less to increase the same. The third grant made to the Wadia Family in the year 1885 by the Indenture of 19th December 1885 is also an absolute grant of the land, rent free in perpetuity but subject as usual only to the payment of all taxes, rates, assessments, duties and charges payable in respect thereof, and the

nature of the estate given to the grantee, viz. the Wadia family is freehold with the usual incidents attached to a freehold estate.

The second grant made to the Lowji family in the year 1828 is, however, not a grant of the soil, but only a grant of the revenues as held by Parsons J. in High Court suit No. 439 of 1889, *C. N. Wadia* v. *E. D. Sassoon & Co.* a view which also appears to be supported by the decision of their Lordships of the Privy Council in the case of *Bomanji J. Wadia* v. *The Secretary of State* (1929) 31 Bom. L. R. 256 = (1929) 53 Bom. where on the construction of the Deed dated the 9th February 1848, their Lordships held that so far as the lands occupied by the ryots or sutidars were concerned, the grant was in effect a grant of the revenue payable by them. It is, however, somewhat difficult to understand the exact nature of the tenure of the grantee under the said grant of 1828. It would appear as if the grantee is not the beneficial owner of the soil, but that he has only been given the power to collect the revenue arising therefrom. It would also appear that the Government would perhaps be entitled to revise and enhance the assessment and that when the assessment is enhanced, on such revision, the Inamdars of the neighbouring and similar lands would also be entitled to enforce a similar enhancement of rent from their tenants the Government claiming no share in the Inamdar's additional receipts. Though the Government at first contested this position, they now seem to have declared that they would not recover the amount of the enhanced assessment either on their own account or interfere with the recovery of it by the Inamdars. The Government have also declared that no claim would be made on their part for the enhancement of the assessment in respect of the lands held as Inams by the Lowji family under the grants of 1783 and 1828.

RAMINKLAL R. MODY,
ATTORNEY-AT-LAW

LIST OF AUTHORITIES.

(1) Doe Dem Mckenzie *v.* Pestonji Dadabhai. Perry's *Oriental Cases*, p. 531.

(2) Doe Dem Mckenzie *v.* Howard Dadabhai. Perry's *Oriental Cases*, p. 535.

(3) Morarji Goculdas Spinning & Weaving Co. Ltd. *v.* The Collector of Bombay, Suit No. 1 of 1921.

(4) C. N. Wadia *v.* E. D. Sassoon & Co., Suit No. 439 of 1889.

(5) E. D. Sassoon & Co. *v.* C. N. Wadia, Appeal No. 629 of 1889.

(6) *The Gazetteer of Bombay City & Island*, (1909) Edition, Vol. II, pp. 374 to 381.

(7) *Vaidya's Land Revenue Code* (1931) 2nd Edition, pp. 105 to 112.

(8) Jamshedji A. Wadia *v.* The Secretary of State for India, (1926) 28 Bom. L. R. p. 25.

(9) Same Case on appeal Bomanji J. Wadia *v.* The Secretary of State (1929) 31 Bom. L. R. p. 256, (1929) 53 Bom. 230.

SCHEDULE A.

Deed of Gift dated 29th May 1828.

This Indenture made the 29th day of May in the year of our Lord 1828 between the Honourable the United Company of Merchants of England trading to the East Indies of the one part and Nowrojee Jamsetjee, Muncherjee Jamsetjee and Dossabhoy Jamsetjee of Bombay, Parsee Inhabitants, sole heirs and representatives of Jamsetjee Bomanjee, late of Bombay, Parsi Inhabitant and master Builder in the Dockyard of the said United Company at Bombay deceased of the other part. Whereas the said United Company in the lifetime of the said Jamsetjee Bomanjee being desirous to testify their approbation of his long eminent and faithful services as Master Builder as aforesaid resolved to grant to him and his heirs certain revenues accruing from and payable to the said United Company for and on account of certain lands situate in the island of Bombay and Salsette and whereas the said Jamsetjee Bomanjee departed this life on or about the 31st day of August in the year of Christ 1821 and before the said resolution could be carried into effect and whereas the said Nowrojee Jamsetjee, Muncherjee Jamsetjee and Dossabhoy Jamsetjee as the heirs and representatives of the said Jamshedjee Bomanjee were afterwards that is to say on or about the 29th day of January in the year of Christ 1822 in pursuance of the said resolution put into possession of such revenues and have ever since continued to receive and enjoy the same but no deed in respect of the grant of that part thereof situate on the island of Bombay has yet been executed and Whereas in order more fully to enable the said Nowrojee Jamsetjee, Muncherjee Jamsetjee and Dossabhoy Jamsetjee and their respective heirs as heirs and representatives as aforesaid to collect and receive such revenues from time to time and at all times hereafter as and when the same shall become due and payable and to enjoy the same as and for their own sole and absolute property the said United Company have agreed to execute these presents. Now this Indenture witnesseth that in consideration of the premises and also of the sum of ten rupees of lawful money of Bombay to the said United Company in hand paid by the said Nowrojee Jamsetjee, Muncherjee Jamsetjee and Dossabhoy Jamsetjee

at or immediately before the sealing and delivery of these presents the receipt of which is hereby acknowledged the said United Company have given granted, bargained, sold, aliened, transferred and assigned and by these presents do give grant, bargain, sell, alien transfer and assign unto the said Nowrojee Jamsetjee, Muncherjee Jamsetjee and Dossabhoy Jamsetjee their heirs executors and administrators all and every the rents and produce sums and sum of money now due and of right payable or which shall or may at any time or times hereafter be or become due and payable as for or in respect of revenues collected or arising on and from the several pieces or parcels of ground and according to the statement next hereinbefore set forth being a statement of moorahs of batty calculated according to an average of 20 years preceding the year 1822 and amounting in value including foras to two thousand rupees yearly as appears by the Collector's statement in that behalf bearing date the 22nd day of January in the year of Christ 1822 that is to say :—

Villages.	Moorahs.	Parahs.	Adolies.	Seers.	Moorahs.	Parahs.	Adolies.	Seers.	Rupees.	Quarters.	Reas.
PAREL											
Dewsett, Batty ground	2	19	15	0							
Harry, grand ...	2	9	1	2							
Collay „ ...	2	2	19	1							
Palut „ ...	1	17	12	1							
Doncolly, grand „	0	12	13	0							
„ small „	0	4	4	2							
Erpeni Reaysensett „	0	21	4	1							
Gosar Sally „	0	1	19	0							
Khuzmall „	5	8	18	0							
Worah Denicha „	0	11	2	1							
Kharell Condem „	0	2	2	0							
Cordum „	2	10	14	½							
Dorgem small „	0	0	7	0							
„ grant „	0	23	14	0	19	21	5	3½	496	1	7½
NAGAO											
Tank batty ground ...	14	3	0	2							
Boroaedeen „ ...	3	5	4	3							
Deguim „ ...	3	6	8	2½							
Sollonurv „ ...	2	0	14	0							
Warah „ ...	1	16	19	3½							
Cother Bhatt „ ...	0	3	2	3½							
Sunwar Bhatt „ ...	0	4	10	0							
Ambewaddy „ ...	0	1	15	0	24	13	16	2	613	3	30

Villages.	Moorahs.	Parahs.	Adolies.	Seers.	Moorahs.	Parahs.	Adolies.	Seers.	Rupees.	Quarters.	Reas.
SION											
Allpom, batty ground ...	2	7	12	0							
Bomoy „ „	0	9	0	1							
Hany „ „	1	11	16	0							
Salsette „ „	4	22	19	0							
Derkin „ „	2	10	13	0							
Malungem„ „	2	22	13	3							
Cuhnary, grand „	5	8	0	0							
Dungery „	1	12	16	0							
Borewshem batty ground	0	13	3	2							
Sagersett „ „	5	24	19	2							
Augurrum „ „	1	11	2	0							
Bhaway „ „	0	15	7	½	30	5	12	½	755	2	42½
MAHIM CASSABHAY											
Nandvan batty ground	...	...	...	...	1	3	0	0	28	0	0
At Rs. 25 per moorah ...			...		75	18	14	2	1,893	2	90
The amount of foras viz.			...		...	rs.	qr.	rs.			
Hormosjee Bomanjee Wadia			...		...	41	0	37			
Cumbla Bhicajee ...			...		...	29	1	0			
Pestonjee Bomanjee Wadia			...		...	30	3	72	101	1	9
									1,994	3	99
Petty income of Nago village ...									5	0	1
Total Rs.									2,000	0	0

To have and to hold receive take and enjoy the said rents and produce sums and sum of money unto the said Nowrojee Jamsetjee, Muncherjee Jamsetjee and Dossabhoy Jamsetjee their heirs executors and administrators henceforth for ever as fully effctually to all intents and purposes and with all such powers remedies and means whatsoever as the said United Company have or ever had or could or might have had taken received and enjoyed the same in case these presents had not been made and the said United Company for themselves and their successors do hereby covenant and agree to and with the said Nowrojee Jamsetjee, Muncherjee Jamsetjee and Dossabhoy Jamsetjee their heirs, executors and administrators in manner following that is to say that for and notwithstanding any act deed matter or thing by the said United Company made done or committed to the contrary they the said United Company have in themselves good right full power and lawful and absolute authority to grant convey and assure the said revenues of the said villages or pieces

or parcels of ground hereinbefore pacticularly mentioned or described unto and to the use of the said Nowrojee Jamsetjee, Muncherjee Jamsetjee and Dossabhoy Jamsetjee their heirs executors and administrators in manner and form as aforesaid and according to the true intent and meaning of these presents and further that for and notwithstanding any such acts matters or thing as aforesaid they the said Nowrojee Jamsetjee, Muncherjee Jamsetjee and Dossabhoy Jamsetjee heir executors and administrators shall and lawfully may from time to time and at all times hereafter peaceably and quietly have hold receive and take the said revenues hereby granted and assigned or intended so to be to and for their own benefit subject nevertheless to the several provisions and declarations hereinafter particularly mentioned and moreover that they the said United Company and their successors and all and every person or persons lawfully claiming or who shall or may claim any estate right title or interest unto or out of the said several villages pieces or parcels of ground before mentioned or any of them or any part or parcel thereof by from or under or in trust for them or any or either of them shall and will from time to time and at all times at and upon the reasonable request and at the proper costs and charges of the said Nowrojee Jamsetjee, Mancherjee Jamsetjee and Dossabhoy Jamsetjee their heirs executors and administrators make do acknowledge execute perform and perfect and furnish and cause and procure to be made done acknowledged executed performed perfected and furnished all and every such further and other lawful and reasonable act and deeds and conveyances and releases and assurances in the law whatsoever for the further better and more perfect and absolute conveying granting and assuring the said premises before mentioned and by these presents granted or intended so to be unto and for the use and behalf of the said Nowrojee Jamsetjee, Muncherjee Jamsetjee and Dossabhoy Jamsetjee their heirs executors or administrators or their or either or any counsel learned in the law shall reasonably be advised or required provided always and this Indenture further witnesseth and It is hereby expressly provided and declared that it shall not be in the power of the said Nowrojee Jamsetjee Muncherji Jamsetji and Dossabhoy Jamsetjee their heirs, executors or administrators or any or either of them or any other person or persons deriving right from any or either of them to the said revenues or any part thereof to increase the present rate of assessment leviable and payable upon and from the said villages and pieces of ground before mentioned or either or of any part thereof and it is also provided and declared that notwithstanding the execution of these presents the Coorumhees shall have hold and retain the right of cultivation of their several possessions as at this present time possessed by them and shall have hold and retain all other pri-

vileges possessed by them so as they are or may be entitled to possess and enjoy to and from the constitution of the said Island of Bombay as fully and effectually to all intents and purposes as if these presents had not been made. And it is further provided and declared that in the event of the land assessment being at any further time increased by the authority of the said United Company or their successors or by the Honourable the Directors of the said United Company or others having proper and effectual authority in that behalf or in case any other modification shall be introduced into the existing revenue system of the said island such alteration shall extend to and have ... ation in the said villages o. pieces of ground before mentioned ... the same manner and as fully in all respects as if these presents had never been made or granted. In witness whereof the said Honourable the Governor in Council at Bombay aforesaid for and on behalf of the United Company hath caused the common seal of the said United Company to be set and affixed the day and year herein above written.

Signed sealed and delivered where no stamps are used or procurable in the presence of (SD.) MATHEW DE CRUZ, (SD.) SOONDER MOROJEE.	(SD.) JOHN BAZ. *Secretary to Government.*

DEED OF GIFT DATED 19TH DECEMBER 1885.

SCHEDULE B.

This Indenture made the 19th day of December 1885, between The Secretary of State for India in Council of the one part and Khan Bahadur Jamsetjee Dhunjibhoy Wadia of Bombay, Parsee Inhabitant of the other part whereas the Government of Bombay in consideration of the exceptional services rendered by the said Khan Bahadur Jamsetjee Dhunjibhai Wadia during his long and useful official career extending over a period of more than 40 years have agreed to grant to the said Khan Bahadur Jamsetjee Dhunjibhoy Wadia the pieces of land hereinafter described. Now this Indenture witnesseth that in consideration of the premises he the said Secretary of State doth hereby grant unto the said Khan Bahadur Jamsetjee Dhunjibhoy Wadia his heirs and assigns Firstly all those two pieces of ground situate at Dharavi Bombay containing altogether by admeasurement Sixteen Acres or thereabouts divided from one another by a strip of land formerly used for the purposes of the Great Indian Peninsula Railway and now reserved for a road the larger of which said pieces of land is bounded on or

towards the North by the Dharavi Road on or towards the South-West by the said strip of land reserved for a road and on the East by the property of private individuals and the smaller of which said pieces of land is bounded on the North-East by the said strip of land reserved for a road and on the South-West by the property of private individuals and which said two pieces of land are more particularly delineated in the map or plan hereto annexed and marked A and are therein coloured pink. Secondly all that piece of ground or swamp and ground covered by sea-water situate at Dharavi containing by admeasurement twenty-eight Acres or thereabouts and bounded as follows that is to say on or towards the South by the said Dharavi Road and on or towards the North-East and West sides thereof by swampt ground and ground covered by sea-water and which said piece of land secondly described is more particularly delineated in the said map or plan marked A and is therein coloured blue and thirdly all that piece of ground or marsh ground situate at Sion Bombay containing by admeasurement two hundred and sixty-three Acres or thereabouts and bounded as follows that is to say on or towards the North and East by a Channel or Creek on or towards the South partly by a salt-pan called Sallamati and partly by unoccupied land belonging to private individuals partly by ground belonging to Cursetjee Nusserwanjee Cama and partly by Duncan Causeway leading from Sion to Coorla and which said piece of ground thirdly described is particularly delineated in the map or plan hereto annexed and marked B and therein coloured red and which said premises firstly secondly and thirdly described are situate in the Registration sub-district of Mandvee But save nevertheless and except out of this present grant the water-course or the free running of or passage for storm and monsoon water in or upon or through the larger of the two pieces of land herein before firstly described from the southernmost point thereof to the sluice gates at the North East corner thereof by the Dharavi Road as shown on the said plan marked A and also except the water-courses or the free running of or passages for water in upon through or along side of the said piece of ground herein before thirdly described to and from the salt-pans and land or ground in the neighbourhood of or adjoining the said piece of ground herein before thirdly described To hold the said premises except as aforesaid unto and to the use of the said Khan Bahadoor Jamsetjee Dhunjibhoy Wadia his heirs and assigns rent free in perpetuity but subject to the payment of all taxes rates assessments duties and charges leviable or chargeable in respect of the said premises or anything for the time being thereon And the said Secretary of State doth hereby for himself his successors and assigns covenant with the said Khan Bahadoor Jamsetjee Dhunji-

bhoy Wadia his heirs and assigns that notwithstanding anything by the said Secretary of State done or knowingly suffered the said Secretary of State Now hath power to grant the said premises unto and to the use of the said Khan Bahadoor Jamsetjee Dhunjibhoy Wadia his heirs and assigns in manner aforesaid free from incumbrances and the said Khan Bahadur Jamsetjee Dhunjibhoy Wadia doth hereby for himself his heirs, executors administrators and assigns covenant with the said Secretary of State his successors and assigns that he the Said Khan Bahadoor Jamsetjee Dhunjibhoy Wadia his heirs executors administrators and assigns will not at any time interfere with the water-courses or the free running of or passages for storm or monsoon water in or upon or through the larger of the two pieces of land hereinbefore firstly described from the southernmost point thereof to the sluice-gates at the North-East corner thereof by the Dharavi Road and will not at any time interfere with the supply of water to the salt-pans in the neighbourhood of the premises thirdly described or the water-courses or the free running of or passages for water in upon through or alongside the said premises to and from the salt-pans and land or ground in the neighbourhood thereof. In Witness whereof the Right Honourable the Governor of Bombay in Council for and on behalf of the Secretary of State for India in Council hath caused one of the Secretaries to the Government of Bombay to set his hand and affix the seal of the said Government hereto and the said Khan Bahadoor Jamsetjee Dhunjibhoy Wadia hath hereunto set his hand and seal the day and year first hereinbefore written.

Signed Sealed and delivered by JOHN NUGENT, Esq., one of the Secretaries to the Government of Bombay in the presence of A. D. ARIA, *Assistant Superintendent, Revenue Department, Secretariat.*	(Sd) J. NUGENT, *Acting Chief Secretary to Government.*
Signed sealed and delivered by the said Khan Bahadur Jamsetji Dhunjibhoy Wadia in the presence of F. A. LITTLE. *Solicitor to Government, Bombay.*	(Sd) JAMSETJEE DHUNJEEBHOY WADIA.

Obituary

Right Honourable Sir Dinshah Mulla.

Ripe scholarship, practical activity and good fellowship were some of the predominant qualities which helped Sir Dinshah Mulla to carve out for himself a corner in the niche of legal fame. In any other country than India, he would have found scope for taking interest in thought for its own sake which men like Balfour, Haldane or Asquith displayed and to busy his mind like theirs, with abstract issues. He found his field whilst on the Bench, too restricted to show the boldness and breadth of conception in dealing with new and novel cases which are to be found in the judgments of Holmes, Brandies and Cardozo. Sir Dinshah's great strength lay in a firm and sane grasp of principles and a deep, accurate, and well-arranged knowledge both of substantive and procedural law and usage.

As an Advocate, although not a dominating personality and not possessing the qualities of soaring eloquence or masterly invective, he created a powerful impression by directness, a disarming frankness which loved to place all one's cards on the table, and an accuracy of statement, greatly appreciated by the Bench.

The secret of his style, whether he was addressing a class of students or conducting a case in Court, or writing a text book, lay in saying what he wanted to say, with precision of language and without waste of words. Codes and Acts are not the product of lawyers but of the law makers. It is, therefore, not surprising that, speaking generally, they are distinguished neither for precision nor clarity of language. Sir Dinshah, both in his commentaries and in his judgments whilst on the Bench, expressed himself with a happiness of language and with a precision which is hard to beat.

Sir Dinshah was connected with the Bombay University, being Principal of its Law College, in Bombay, for some years. The remark that a deaf law student listening through an ear trumpet to the lectures delivered by professors at the Government Law School, was guilty of a wanton waste of the mercies of Providence, was never spoken of Sir Dinshah's lectures.

Throughout his life, Sir Dinshah continued to be a student, and maintained an open and a willing mind ready to imbibe new ideas and to learn. This quality rendered him eminently engaging and accessible, particularly to law students at all times. Notwithstand-

By courtesy of "The Bombay Law Reporter."]

THE RIGHT HONOURABLE

SIR DINSHAH FARDUNJI MULLA, P.C., KT., C.I.E., LL.D.

ing many calls on his time and energies, he spared neither himself nor his purse when the requirements of a student were concerned. The writer gratefully cherishes the memory of a kind act on the part of Sir Dinshah when a professor at the Law College. Sir Dinshah, at one of his lectures on the Law of Torts announced his intention to award a prize of Rs. 250 to the best essay on "The Law of Torts in relation to the Law of Crimes", the length of the essay to be about 100 pages and the essay to be submitted within six months. The writer made an attempt and sent in the result of his effort to Sir Dinshah on the last day of the competition. Some days later, he received a note from Sir Dinshah in which he stated that the essay did not come up to mark but that he had decided nevertheless to award the prize to the writer, as an encouragement to the study of law. In due course a meeting was held in the Elphinstone College Hall at which Sir Narayan Ganesh Chandavarkar presided and the writer had the good fortune to receive Sir Dinshah's cheque for the amount of the prize, at the hands of the learned President. The above is one of the many acts of kindly generosity on the part of Sir Dinshah Mulla, which will keep his memory green in the hearts of many generations of law students.

Law is a living science, drawing its vigour from current social and economic activities. Codification and an undue dependence on case-law and *stare decisis* tend to cramp its growth. It will, therefore, always remain a matter of regret that it was not found possible for the Bombay University which conferred the degree of LL. D. on Sir Dinshah to obtain his active services for studying and reporting on the present system of law teaching in Bombay, both as regards the matter and the manner, and upon the larger question of bringing about a co-ordination and organic union of all the law colleges throughout India, so as to make Law and Lawyers render a greater and better contribution than heretofore, to the welfare of society and advancement of social justice.

Sir Dinshah was a living embodiment of the highest traditions of the Bar. The spirit of the following oath recommended by the American Bar Association, (substituting "Great Britain and British India" for "the United States") intensely dominated throughout the professional career of Sir Dinshah Mulla :—

"I will support the constitution of the United States and the constitution of the State of—;

"I will maintain the respect due to Courts of Justice and judicial officers:

"I will not counsel or maintain any suit or proceeding which shall appear to me to be unjust, nor any defence except such as I believe to be honestly debatable under the law of the land;

"I will employ for the purpose of maintaining the causes confided to me such means only as are consistent with truth and honor, and will never seek to mislead the Judge or Jury by an artifice or false statement of fact or law;

"I will maintain the confidence and preserve inviolate the secrets of my client, and will accept no compensation in connection with his business except from him or with his knowledge or approval;

"I will abstain from all offensive personality, and advance no fact prejudicial to the honor or reputation of a party or witness, unless required by the justice of the cause with which I am charged;

"I will never reject, from any consideration personal to myself, the cause of the defenceless or oppressed, or delay any man's cause for lucre or malice.

"So Help me God."

Sir Dinshah's sympathies were catholic. His tastes were refined. With all his learning, he had modesty of judgment. Altogether, his personality had a charm all its own. His loss will be long felt by the profession.

N. H. PANDIA,
M.A., LL.B.,
Attorney-at-Law.

Reviews

The Indian Theatre, its origins and its later developments under European influence, with special reference to Western India, by Dr. R. K. YAJNIK, M.A., Ph. D. (London): George Allen & Unwin, Ltd., London.

This work, under the title 'The influence of British Drama on the Indian stage, with special reference to Western India,' was originally designed for a thesis which Dr. Yajnik submitted for the degree of Ph. D., at the London University. The work, as now published, is divided in two parts: the second part incorporates the original thesis proper, while the first part adds a brief and rapid survey of the ancient Indian Drama and Theatre.

Unfortunately so little has been written about the ancient Indian Dramaturgy and Theatre that it becomes very difficult for ordinary persons to judge the ancient Indian theatrical conditions correctly. It is, therefore, commendable that Dr. Yajnik, in Part I, has summarised the conclusions arrived at by the Sanskrit students. Of course, in so doing, he had to resort to such very scanty materials as are available and it is quite likely if in certain places his statements do not receive the approval of the Sanskritists.[1]

In Part II, Dr. Yajnik is more at home, that being the particular subject of his research. It is here that his labour and patience in collating vastly scattered materials are evident.

Modern Indian Theatre has been developing for the last fifty years and more and it is safe to state that the vernacular Drama of modern India, in its dramaturgical technique, has drawn more from the Western Theatre, than from the ancient Indian Theatre. This branch of study, if pursued, would prove very interesting and fruitful. Dr. Yajnik, here, has chosen to examine the influence of British dramas on the modern Indian dramas. In so doing, he has first traced the rise of modern Indian Drama in the various provinces, *e. g.* Gujarat, Deccan, Bengal and then discussed the present peculiar features of the Indian Theatre. After thus giving a complete idea of the Indian Theatre as it now exists in the different provinces, he has enumerated and discussed the stage-versions of Shakespearean and non-Shakespearean dramas in India. Some of his conclusions noted below will give an idea of his main work.

1. E. g. P. 41 (re. place of orchestra), P. 43 (re. the curtain), P. 49 (re. time of production), etc.

"...... out of the seventeen comedies (keeping apart the English Chronicle plays) of Shakespeare, thirteen were staged on the Marathi stage, eight on the Urdu stage and only five on the Bengali stage in India. Out of those remaining, *Love's Labour Lost* has been adapted into Urdu and *Much Ado About Nothing* into Marathi. A Marathi version of *Pericles* (*Sudhanvā*) is extant, although only the Urdu rendering was staged. Thus, in the whole range of Shakespearean comedy only *Troilus and Cressida* remains unaccounted for. The palm naturally belongs to the Marathi theatre." (p. 149).

"......... out of the ten Shakespearean tragedies (apart from the English Chronicle plays) eight were staged in India; while out of the two remaining Roman tragedies *Julius Caesar* was translated and adapted into Bengali and Marathi, though not produced. Only *Coriolanus* was left unrendered." (p. 180).

Thus he has tried to show the influence of British dramas on our modern dramas. It will be seen that in the case of wholesale translations or adaptations, the question of influence is clear enough, but Dr. Yajnik has also shown that there is a subtle element of psychological influence which too has been working on the modern Indian Theatre. In many modern Indian dramas, there are found situations, scenes, dialogues etc., which are directly or indirectly influenced by some such similar portions in the Western plays. Dr. Yajnik has devoted one whole chapter to the examination of this question and this is perhaps the most valuable part of the book.

The history of Indian Drama from the most ancient periods to the modern times has not been a continuous one. Sanskrit Drama was a full-grown drama, but its Prakrit successor has no evidence of full-grown existence. Indian Drama, in the Prakrit and early vernacular age, *i. e.* in the last seven to nine centuries, has experienced a continuous degeneration. Revival in the Indian Drama came with the British rule and unfortunately the pioneers of our modern dramatic revival slavishly imitated the foreign models and produced a type of Drama which is not national. It is, therefore, that on reading Parts I and II of this book, there is seen no connecting link between the two periods. And as long as our dramatic revival does not take its stand on our own past models (taking western models only for the elements wanting therein), we can have no national theatre. In such circumstances, every attempt at a real understanding of our present dramatic conditions, should be welcome. Dr. Yajnik's is a pioneer work in this direction and as such deserves all possible credit.

D. R. MANKAD

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* Only Nos 1, 4 and 5.

† All the issues except No. 2.

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The Chief, Scientific Library Division, P. O. Box 774, Manilla P. I.

The Director of the Psychological Institute, Sendai, Japan.

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